TAXONOMY AND DISTRIBUTION OF THE GENUS RORIPPA (CRUCIFERAE) IN NORTH AMERICA[1]

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Rorippa consists of those yellow-petaled, numerous-seeded, readily-dehiscent-fruited marsh and shore plants in the Cruciferae. Distributed primarily in temperate, less so in subtropical and tropical regions, the genus occurs on every continent except Antarctica, but the species are more numerous in the northern hemisphere. The number of valid species is usually given as between 40 and 50, but this number may increase to 60 or 70 with expanded knowledge. Jonsell (1968) considered there to be about 70 species, some imperfectly known. One highly variable species, *R. palustris*, is known from each continent where the genus occurs. Busch (1915) discussed and mapped seven species for Eurasia; Wannenmacher (1960) had eight species for Middle Europe; and, in *Flora Europaea*, Valentine (1964) included 10 species. Several species are known from southern Asia, Africa, and South America. I recognize 21 species and 25 varieties (including typical ones) as native to North America; seven species are considered as introduced. The evolutionary relationship of these foreign members to the North American species is not understood.

In North America, *Rorippa* is most common and abundant, both as to individuals and taxa, in the mountainous regions of western United States. The plants usually grow in open, damp or wet, naturally-disturbed habitats along sandy shores of lakes and alluvial banks of creeks, streams, and rivers, and in marshes and swales; or in wet artificially-disturbed sites along roadside, drainage, and irrigation ditches, about edges of farm ponds, in low fallow or cultivated fields and gardens, along railroad grades and ditches, and about dumps or on ballast.

HISTORY OF THE GENUS

The yellow cresses have a confused nomenclatural history. *Rorippa* begins with Scopoli (Fl. Carn. ed. 1. 520. 1760), who wrote the first, but brief, generic diagnosis. Although he did not provide binomials, three species were named. The first contains the exact phraseology as that provided by Linnaeus (Sp. Pl. 675. 1753) for *Sisymbrium sylvestre*. Scopoli cited Linnaeus as one of five sources; on this basis, *Rorippa sylvestris* (Linnaeus) Besser is taken as the type of the genus. Abrams (1944) listed *Sisymbrium am-*

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phibium Linnaeus as the type, a selection for which I find no basis, since Scopoli made no reference to this species. Included in Linnaeus' concept of *Sisymbrium* (16 species) were members of present-day *Sisymbrium* and *Rorippa* and also watercress (*Nasturtium*). Mackenzie (1925), in a review of Linnaeus' *Sisymbrium*, noted that these 16 species have been placed in nine to 11 different genera. Linnaeus treated two species of present-day *Rorippa*, *S. sylvestre* and *S. amphibium*. To the latter he appended three varieties, α *palustre*, β *aquaticum*, and δ *terrestre*. Pollich (Hist. Pl. 230. 1777) raised α *palustre* to specific rank in *Sisymbrium*, and, later, Besser (Enum. Pl. Volh. 27. 1822) transferred the epithets *palustre*, *amphibium*, and *sylvestre* to *Rorippa*.

In proposing the genus *Brachiolobus* (sometimes spelled *Brachilobus*, *Brachyolobos*, or *Brachylobus*) Allioni (Fl. Pedem. 1: 278. 1785) cited *Radicula* of Dillenius (Gen. Pl. Nov. 121. 1719) as the basis for his concept. Included in the original account were three species, *B. amphibius, B. sylvestris*, and *B. pyrenaicus*. *Rorippa* Scopoli is treated as a synonym of *B. sylvestris*. Allioni's species are now placed in *Rorippa*, and so there is no doubt that *Brachiolobus* is a synonym of *Rorippa*, as all subsequent authors have considered it.

As early as 1719—34 years before *Species Plantarum*—Dillenius (Gen. Pl. Nov. 121) was, according to Greene (1905), the first to characterize the yellow cresses as a genus under the name *Radicula*. Hill (Brit. Herbal 264. 1756) took up the name *Radicula*, but his specific names are not valid because he did not use the binomial system or refer to a work that did. It was not until 1794 that Moench (Meth. 262. 1794) provided and validated the specific epithets under *Radicula*. Those botanists who advocated strict priority or did not follow the code used *Radicula*. Greene (1905) and Mackenzie (1929) argued for its use, and many North American authors formed combinations under it. However, according to the *International Code* (Article 20), "The name of a genus may not coincide with a technical term currently used in morphology unless it was published before 1 Jan. 1912 and was accompanied, when originally published, by a specific name published in accordance with the binary method of Linnaeus." The name *Radicula* coincides with the technical term *radicula* (radicle) and, when originally published, was not accompanied by a specific name in accordance with the Linnaean method (Hill, Brit. Herbal 264. 1756). Moench (Meth. 262. 1794), who validated the genus, included the type species of the older generic name *Rorippa* (Scopoli, Fl. Carn. ed. 1. 520. 1760). In accordance with the rules, *Radicula* Moench must be rejected in favor of *Rorippa* Scopoli. The code cites this situation as an example to illustrate this rule.

Robert Brown in Aiton (Hort. Kew. ed. 2. 4: 109. 1812) enlarged the concept of the yellow cresses to include the white-flowered watercress, and he proposed the generic name *Nasturtium*. Included in this concept were not only watercress (*Nasturtium officinale* R. Brown) but also *N. sylvestre, N. terrestre, N. amphibium*, and *N. pyrenaicum*, all based on Willdenow (Sp.Pl. 3: 489. 1800), whose epithets in turn were taken from Linnaeus (Sp. Pl. 657.

1753). *Nasturtium* was long used for both the yellow cresses and watercress, but later workers, as pointed out by Sprague (1924), regarded watercress as a genus separate from yellow cresses; as a result, the older name *Baeumerta* Gaertner, Meyer, and Scherbius (Fl. Wett. 2: 419. 1800) was revived for the former. This led Janchen to propose that the name *Nasturtium* be conserved for watercress (Prop. Amplif. Liste Nom. Gen. Conserv. 4. 1909), and at the Brussels Congress of 1910, *Nasturtium* was added to the list of *nomina conservanda.* At that time only two *nomina rejicienda* were listed—*Cardaminum* Moench (Meth. 262. 1794) and *Baeumerta.* Since then, *Nasturtium* Miller (Gard. Dict. Abr. ed. 4. 1754) has been added to the list. I regard watercress as a genus separate from *Rorippa* (*see* section on "Relationships to Other Genera").

DeCandolle (Syst. Nat. 2: 188. 1821) first attempted to bring together, under *Nasturtium,* knowledge of watercress and the yellow cresses. The genus was subdivided into three sections on the basis of petal color and size and silique shape. Section *Cardaminum* contained watercress, *Nasturtium officinale,* white flowered. Section *Brachylobus* included the yellow cresses with short or ellipsoid siliques—the species around which the concept of *Rorippa* began, e.g., *N. sylvestre, N. palustre,* and *N. amphibium.* Section *Clandestinaria* contained plants devoid of petals or with small white petals, and elongate siliques. This was a dubious group of entities of Asia and South America whose relationships are little understood. None of them is native to North America; they are not considered in my paper. DeCandolle's work predominated, and so many species described from North America during early exploration were put in *Nasturtium.* Schulz in Engler and Prantl (*Die natürlichen Pflanzenfamilien,* ed. 2, 17b: 551. 1936) used the name *Nasturtium* and followed DeCandolle in characterizing the sections. Jonsell (1968) reviewed Schulz's treatment.

A further problem causing much confusion arose when Scopoli (Fl. Carn. ed. 2. 2: 24, 25. 1772) employed the spelling *Roripa* instead of *Rorippa* as published in his first edition (Fl. Carn. ed. 1. 520. 1760). Adanson (Fam. Pl. 2: 417. 1763) also used *Roripa.* Schinz and Thellung (Viert. Nat. Ges. Zürich 53: 537. 1909) and Knowlton and Deane (Rhodora 18: 200. 1916) accepted *Roripa* on the ground that *Rorippa* was a typographical error later corrected by its author. A number of North American authors used *Roripa.* However, Briquet (Prodr. Fl. Corse. 2: 28. 1913) pointed out that there was no evidence to indicate a typographical error, and he adhered to the original spelling, *Rorippa.* As to the source of the name, Scopoli provided the reference "Nomen Genericum Gesnerianum est," but no botanist knew to what work this referred, until Sprague (1930) discovered the source of the name—it was spelled *Rorippa.*

North American *Rorippa* has had little study. Torrey (1857) pointed out that the North American species needed careful revision. His statement was made 41 years after Desvaux (1814) named *Brachilobus* [sic] *hispidus,* the first entity described from North American material. In the intervening years, several species were proposed, but the treatment of 15 species under

Nasturtium by Torrey and Gray (1838-1843) was the first summary of these plants for the continent. Later, Watson (1895) prepared a treatment for the continent of ten species and seven varieties, which was slightly revised by Robinson. Aside from this work, no detailed study dealing strictly with the genus in North America has ever been undertaken. Various workers contributed small papers, but most of these were prepared on a local or regional basis. For example, regional revisions, no two being in agreement, were prepared for the *Rorippa palustris* complex by Marie-Victorin (1930), Butters and Abbe (1940), Fernald (1928, 1940), and Hultén (1945). Rollins (1941, 1961) contributed papers dealing primarily with members here placed in section *Sinuatae*. Nearly 100 years after Torrey's call for a study of North American *Rorippa*, a number of writers, including Hultén (1945), Harrington (1954), Mason (1957), and Rollins (1960, 1961), continued to point out the need for a detailed study.

SCOPE OF THE PRESENT STUDY

Data, primarily morphological and geographical, were obtained and correlated from: (1) examination of over 6000 herbarium specimens, (2) field studies in the Rocky Mountains and Great Lakes regions of the United States, (3) greenhouse observations on approximately half of the North American taxa, and (4) literature survey, each reference examined in the original or in photocopy. Important morphological characters for delimiting the taxa of North American *Rorippa* are: (1) fruit size and shape, (2) style length, shape, and mode of attachment to the silique, (3) pedicel position and length in fruit, (4) petal length, and length in relation to the sepals, (5) manner of raceme development, (6) trichome types and location, (7) leaf shape and lobing, (8) seed size, surface markings, and number per silique, and (9) replum shape. For the most part, descriptive terminology follows Lawrence (1951), Featherly (1954), and recent papers by Rollins (1941, 1961). Seed terminology is based on Murley (1951). All measurements given were made on herbarium specimens. Measurements of reproductive structures were usually made from among the mature lower five pedicels, siliques, and styles of the terminal raceme on those plants which have one, or on the lowest lateral raceme of those plants without terminal racemes. Because most herbarium specimens are in fruit, measurements of flower parts necessarily had to be made on flowers present in the upper portion of the raceme.

Pedicel position was resolved into three categories: (1) Recurved. These leave the raceme axis at right angles and then bend downward slightly or very strongly. Sometimes they may even bend back over the axis, and the siliques then appear to be borne unilaterally. (2) Divergent. These diverge from the axis at angles of about 65° to 90°. (3) Ascending. These diverge from the axis at angles less than 65°.

Silique width was measured at about 2/3 of the way up from the base of the silique perpendicular to the replum. Therefore, the width measurements are often slightly wider than the width of the replum or the valve.

Style lengths in fruit are quite variable. Those mostly over 1 mm. long are found in section *Sinuatae*; those mostly under 1 mm. long, in section *Rorippa*. To distinguish species within section *Rorippa* on the basis of style length, as is sometimes done in manuals, is often meaningless. Style shape and mode of attachment to the silique apex are more significant. The three basic style types are discussed in the summary of section *Rorippa* and are illustrated in figure 8-B. These styles show the unexpanded stigma condition —the stigma in fruit is no wider than the style apex. A stigma is considered expanded in fruit when it is wider than the style apex, e.g., in *R. palustris* subsp. *palustris* var. *palustris* and subsp. *glabra* var. *fernaldiana*.

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SOURCES OF HERBARIUM SPECIMENS

I am grateful to the curators of the following herbaria whose specimens were studied for my dissertation: A, BLH, FSU, GH, HAM, MICH, MO, MSC, ND, ND-G, NEBC, NY, OC, OS, PH, UMBS, US, USFS, WIS, and WUD. A few critical or type specimens were seen from BM, ISC, JEPS, K, POM, RSA, and WS.

My original set of specimens collected in western United States in summer 1963 is deposited at MICH. Duplicate sets in various degrees of completeness are at GH, UPS, DAO, WIS, WTU, US, NY, DUKE, and OS.

Since I wrote the dissertation (1965), additional specimens have been seen from the following herbaria: LAF, MICH, PENN, WVA, Arizona State University (Tempe), and Ohio University (Athens). Significant data from these specimens have been incorporated into the text or maps.

To conserve space, citation of specimens examined is not included in this paper. I shall be pleased to send a list of these specimens to anyone who requests it.

SOURCES OF BASE MAPS

Maps 1, 19, 20: compiled by the author. *Maps 2, 4, 5, 6, 9, 11, 12, 13:*

United States. Museum of Zoology, Univ. Michigan, modified from map of United States by U. S. Geol. Surv. 1932. *Map 3:* Mexico, No. 112. Goode's Series of Base Maps, Univ. Chicago. Date unknown. *Maps 7, 14:* United States, No. 209. Goode Base Map Series, Dept. Geog., Univ. Chicago. 1961. *Map 8*: Caribbean America. Source unknown. *Map 10*: Caribbean America, No. 900H. Hall's Outline Maps and Graphs, John Wiley & Sons, Inc., New York. 1935. *Maps 15, 16, 17, 18, 21, 22*: North America, No. 202. Goode Base Map Series, Dept. Geog., Univ. Chicago. 1961.

THE GENUS RORIPPA

GENERIC DESCRIPTION (NORTH AMERICAN SPECIES)

RORIPPA Scopoli, Fl. Carn. ed. 1. 520. 1760.

Brachiolobus Allioni, Fl. Pedem. 1: 278. 1785.

Radicula Dillenius ex Moench, Meth. 262. 1794.

Nasturtium R. Brown, Hort. Kew. ed. 2. 4: 109. 1812. [p.p.]

Tetrapoma Turczaninow ex Fischer et Meyer, Ind. Sem. Hort. Petrop. 1: 39. 1835.

Tetracellion Turczaninow ex Fischer et Meyer, Ind. Sem. Hort. Petrop. 1: 39. 1835, pro syn.

Plants summer, fall, winter, or spring annuals, seldom biennials, from a slender to thick vertical taproot, or perennial from spreading slender to thick underground roots and stems. Secondary roots slender, fibrous, much branched. Stems 1-6(14) dm. tall, one to many, often from the center of a well-developed basal rosette, erect, decumbent, or prostrate, unbranched or much branched from the base and upward on the stem, glabrous, sparingly to densely villous, hirsute, pilose, or with scattered vesicular trichomes. Basal and lower cauline leaves sessile to short-petiolate, alternate (1-3 phyllotaxy), simple, oblong, obovate, oblanceolate, lanceolate to spatulate in outline, mostly 4-12 cm. long, 1-3 cm. wide; the margins entire, crenate, irregularly serrate, repand, laciniate, or dentate, or variously pinnatifid, sinuate, lyrate, or pectinate; middle lobes linear, elliptic, oblong to obovate in outline and with margins entire, crenate, or minutely to coarsely dentate; either or both leaf surfaces smooth or occasionally rough with hyaline ridges, glabrous or sparingly to densely hirsute, occasionally pilose, villous, puberulent, or with vesicular trichomes; leaf base attenuate to cuneate, somewhat auriculate with rounded to pointed lobes, glabrous to sparingly pubescent, slightly clasping the stem to non-auriculate, nonclasping; leaf apex acute to obtuse. Upper cauline leaves usually similar in shape, margins, dissection, and pubscence, but gradually reduced in length and width in comparison to the lower cauline leaves. Racemes terminal and lateral, forming during or after stem elongation, the siliques therefore nearly equal in age (development) at corresponding points on all racemes, or the oldest siliques on the lower portion of the terminal raceme; or racemes lateral, developing during stem elongation in the axils of the lower leaves and progressing upward, without the formation of a true terminal raceme, the oldest siliques on the lower axillary racemes. Pedicels 0.5-13.5 mm. long in fruit, slender, slightly to strongly recurved, divergent, or ascending, often somewhat expanded at the summit, glabrous to sparingly hirsute, rarely pilose, or with a few vesicular trichomes. Sepals ovate, lanceolate, or oblanceolate to oblong, 0.6-4.7 mm. long, 0.4-2 mm. wide, green, often tinged purple to red, becoming yellow to brown upon aging, with hyaline and entire margin, strongly saccate to flat, glabrous to minutely hirsute or rarely pilose in bud, persistent or caducous in fruit. Petals absent or present, obovate, oblanceolate, oblong, narrowly or broadly spatulate, 0.6-6 mm. long, 0.1-2 mm. wide, shorter, equal to, or longer than the sepals, erect or spreading between the sepals during full anthesis, sometimes slightly notched at the apex, cuneate at base, rarely sharply differentiated into blade and claw, pale to bright sulfur yellow, becoming white upon drying, glabrous, caducous in fruit. Stamens 6, slightly tetradynamous, rarely 3-5, the two shorter ones with a pair of minute glands at the base, the longer ones separated by a short conic gland; filaments 0.8-3.1 mm. long, slender, glabrous; anthers 0.5-1.5 mm. long, introrse, crowded against the stigma at anthesis, retained within the flower, glabrous, either globose to subglobose, ca. 1-1.5 times as long as wide and notched at the apex, or elongate, sagittate at a wide base, tapering toward the apex, ca. 1.5-3 times as long as wide and apiculate. Ovary cylindrical, elongating in fruit. Style very short, elongating and persistent in fruit. Ovules numerous. Siliques plump, short to elongate-cylindrical, ellipsoid, or slightly constricted at the middle, oblong, or subglobose to globose; the long ones straight or slightly to strongly falcate, obtuse, cuneate, or acute below, strongly tapering to not at all tapering, or clavate toward the apex, 0.8-20 mm. long, 0.5-3.5 mm. wide, as long as to several times longer than wide, less than, equal to, or longer than the subtending pedicels. Valves 2, sometimes 4, rarely up to 6, thin, turgid, strongly convex, usually readily dehiscent, or rarely indehiscent, non-elastic, nerveless or obscurely nerved, smooth or occasionally rough with hyaline ridges, glabrous, minutely to strongly papillose or rarely sparingly to densely pilose or strigose. Replum narrowly rectangular, elliptic, triangular, or circular in outline, sometimes twisted upon drying, margin straight, concave, or convex, glabrous, hirsute, or with vesicular trichomes. Style nearly absent to prominent, 0.1-1.6 mm. long, 0.1-1 mm. wide in fruit, straight throughout, expanded or tapering toward the apex, abruptly attached or gradually merging into the rounded, obtuse, acute, or pointed silique apex, glabrous or rarely sparingly pilose. Stigma expanded or unexpanded in fruit, unlobed to obscurely 2-lobed. Seeds regularly to angularly cordiform or oblong, ca. 0.4-1.1 mm. long, wingless, numerous and crowded into 2 irregular rows filling the locules, 10 to over 200 per silique; surface reddish or yellowish brown, colliculate, foveolate, or reticulate-foveolate; cotyledons accumbent. Flowering and fruiting mostly from May to September in central and northern United States, Canada, and Alaska; mostly from December to May and occasionally into the summer in southern United States, Mexico, Central America, and the West Indies.

Type species: *R. sylvestris* (Linnaeus) Besser.

The yellow petals and small, numerous, reddish to yellowish brown, mostly colliculate, foveolate, or reticulate-foveolate seeds, in two irregular rows in each locule; the usually two convex, non-elastic, obscurely nerved valves; and the usually readily dehiscent silique distinguish *Rorippa* from related genera.

RELATIONSHIPS TO OTHER GENERA

Rorippa apparently has close affinities with *Nasturtium*, *Armoracia*, and *Cardamine*. A study of the affinities of these and other Cruciferae is needed. *Nasturtium*, the genus of watercress, has been treated in *Rorippa* by authors in both Europe and America, the most recent treatment for North America being by Green (1962). The native North American species of *Rorippa* do not show a close relationship to *Nasturtium*. The distinguishing characters for watercress are the long white petals, prominently reticulate seeds, and somewhat fleshy, glabrous, pinnate leaves with round to oblong, usually entire lobes. The plants, typically aquatic, produce extensive creeping or floating stems often rooting at nodes. *Rorippa* is largely confined to freshwater strands and produces roots at the nodes only when by chance (e.g., after a rise in water level of the lake or river) submersed in water for a period of time.

Armoracia, at least *A. aquatica*, is separated from *Rorippa* by its usually submersed leaves pinnately dissected into numerous filiform segments. When these readily deciduous leaves become separated from the parent plant, they may produce new plants at the base (LaRue, 1943). Although stems of several *Rorippa* are known to form roots at the nodes when in water, the leaves are not known to grow roots or form young plantlets. Other characters that distinguish *A. aquatica* from *Rorippa* are the white petals and the vestigial replum.

Cardamine differs from *Rorippa* in having white, pink, or purple petals, flattened elastic valves, and usually oval, oblong, or subrectangular seeds in one row in each locule of the straight silique.

KEY TO SECTIONS OF RORIPPA (NORTH AMERICAN SPECIES)

1. Basal rosettes wanting even in young plants; lower cauline leaves mostly sinuate-lobed, thick, fleshy, gray, dark green in living plants. . . . . SINUATAE (species 1-6)

1. Basal rosettes present in young plants; basal and lower cauline leaves mostly unlobed to variously laciniate, pinnatifid, lyrate, or pectinate, rarely sinuate-lobed, thin, not fleshy, bright green in living plants. . . . . RORIPPA (species 7-21)

KEY TO SPECIES OF RORIPPA IN NORTH AMERICA

1. Pedicels subtended by leafy bracts. (Asian, one collection from ballast on Vancouver Island). . . . . 27. *R. microsperma*

1. Pedicels not subtended by leafy bracts (2)

    2. Siliques 4- to rarely 6-valved; style in fruit thick, 0.5-1 mm. wide;

stem villous, especially on lower portion. (Mostly on unglaciated territory of Alaska and Yukon). . . . . . . 21. *R. barbareifolia*

2. Siliques 2-valved; style in fruit slender, 0.1-0.5 mm. wide; stem glabrous, sparingly to densely hirsute, pilose, or with vesicular trichomes (3)

3. Petals absent (4)

3. Petals present (6)

4. Pedicels longer than 4 mm.; siliques 10-25 mm. long; style in fruit longer than 0.5 mm. (Sporadic, apparently introduced from tropical areas of South America). . . . . 28. *R. heterophylla*

4. Pedicels shorter than 3.2 mm.; siliques 3-8.5(10) mm. long; style in fruit shorter than 0.5 mm. (5)

5. Plants glabrous; valves smooth to rough with minute hyaline ridges, glabrous; seeds light yellowish brown, deeply foveolate, usually more than 150 per silique; leaves sessile, obovate, oblong, oblanceolate to spatulate, the margins entire, crenate, irregularly serrate or repand, not pinnatifid; siliques nearly equal in age (development) at corresponding points on the terminal and lateral racemes. (Mostly south of the southern limit of Wisconsin glaciation in the Mississippi embayment and southeastern United States). . . . . 13. *R. sessiliflora*

5. Plants with hemispherical or obovate to clavate vesicular trichomes; valves smooth to rough with minute hyaline ridges or with hemispherical vesicular trichomes; seeds dark reddish brown, somewhat reticulate to shallowly foveolate, usually fewer than 100 per silique; leaves petiolate, oblong to oblanceolate, pinnately divided nearly to the midrib, the lobes oblong to elliptic, the margins entire, deeply crenate, or angularly toothed; oldest siliques on lower axillary racemes. (West Indies). . . . . 12. *R. portoricensis*

6. Petals shorter than or equal to the sepals (7)

6. Petals longer than the sepals (17)

7. Seeds less than 0.5 mm. in length; vesicular trichomes present on lower portion of stems, upper surface of basal and lower cauline leaves, pedicels, or siliques (8)

7. Seeds more than 0.5 mm. in length; vesicular trichomes (not necessarily other types) absent from all parts of the plant (9)

8. Style in fruit longer than 0.5 mm.; pedicels (1.4)2.5-4.5(5.2) mm. long, usually longer than 2.5 mm.; seeds usually more than 100 per silique. (Coastal Plain of southern United States and Mexico and sparingly on east coast of Central America). . . . . 11. *R. teres*

8. Style in fruit shorter than 0.5 mm.; pedicels (0.6)1-2.2(3) mm. long, usually shorter than 2.2 mm.; seeds usually fewer than 100 per silique. (West Indies). . . . . 12. *R. portoricensis*

9. Petals usually longer than 1.2 mm.; oldest siliques on lower portion of the terminal raceme. (Mostly throughout North America north of Mexico). . . . . 20. *R. palustris*

9. Petals usually shorter than 1.2 mm.; oldest siliques on lower axillary

racemes, or siliques nearly equal in age (development) at corresponding points on the terminal and lateral racemes. (Occasionally in *R. pinnata* and in *R. intermedia* of Mexico and Central America, the oldest siliques may be on the lower portion of the terminal raceme) (10)

10. Replum margin minutely hirsute and the valves readily dehiscent, or if replum margin glabrous, the valves not readily dehiscent; pedicels and stem often with slender, short, retrorse, pointed trichomes; petals spreading between the sepals in living plants. (Mostly west of the Continental Divide in North America). . . . . 8. *R. curvisiliqua*

10. Replum margin and pedicels glabrous; valves readily dehiscent; stems occasionally with a few scattered, but not retrorse, trichomes below; petals erect in living plants (11)

11. Siliques globose, 1-1.3 times as long as wide; replum circular in outline. (Scattered throughout southwestern United States). 19. *R. sphaerocarpa*

11. Siliques short- to elongate-cylindrical, 1.5-5 or more times as long as wide; replum oblong to triangular in outline (12)

12. Plants mostly shorter than 3 dm., prostrate to decumbent; cauline leaves usually fewer than 10; oldest siliques on lower axillary racemes, or if about equal in age at corresponding points on the racemes, the valves minutely papillose (13)

12. Plants mostly taller than 3 dm., prostrate, decumbent, or erect; cauline leaves usually more than 10; oldest siliques on lower portion of the terminal raceme, or siliques nearly equal in age at corresponding points on the terminal and lateral racemes, the valves glabrous (14)

13. Siliques rough with minute papillae, tapering to the apex, slightly curved inward, occasionally curved outward, not constricted at the center, (2)3.5-7(8.5) mm. long, ca. 1.5-2.5(4) times as long as wide; style in fruit thick, ca. 0.2-0.4 mm. wide, tapering toward the apex, gradually merging into the pointed silique apex; leaves lyrate divided, the margin entire. (Central Nevada and Utah, southern and Lower California, eastern Idaho, western Montana, and in the Columbia, Platte, Rio Grande, and Missouri river valleys, often growing with R. truncata). 7. *R. tenerrima*

13. Siliques glabrous, not at all or only slightly tapering toward the apex, straight, constricted at the center, (2.3)3-5(8.2) mm. long, ca. 2-4.2(6) times as long as wide; style in fruit slender, ca. 0.1-0.2 mm. wide, straight throughout, abruptly attached to the obtuse to truncate silique apex; leaves pinnate-divided to the midrib, the margin angularly toothed. (Central and southern California, eastern Arizona, northeastern Idaho, western Montana, Columbia, Platte, Rio Grande, and Missouri River valleys, often growing with R. tenerrima). . . . 17. *R. truncata*

14. Cauline leaves unlobed, the margin entire, crenate, irregularly serrate or repand. (Abundant in the Rocky Mountains of the United States mostly below 9000 ft., occasional westward, and sparingly

eastward) . . . . 18. *R. curvipes*

14. Cauline leaves pinnately divided to the midrib, the margin mostly angularly toothed. (Extreme southwestern United States, south through Mexico to Costa Rica) (15)

15. Siliques 6.7-11 mm. long, 2-4 times as long as the pedicels; seeds 0.8-1.1 mm. long, coarsely colliculate. (Mountains of central Costa Rica north to Guatemala). . . . . 14. *R. megasperma*

15. Siliques 2.7-6.5 mm. long, 0.8-1.5 times as long as the pedicels; seeds 0.5-0.8 mm. long, finely colliculate (16)

16. Pedicels recurved; siliques thick, (1.1)1.4-2.3 mm. wide; seeds 0.7-0.8 mm. long, usually more than 30 per silique; lower surface of the leaves smooth. (Central Valley of Mexico, south to Guatemala). . . . . 15. *R. pinnata*

16. Pedicels divergent to erect; siliques narrow, 0.7-1.3 mm. wide; seeds 0.5-0.6 mm. long, usually fewer than 20 per silique; lower surface of the leaves rough with hyaline ridges on the midrib. (Extreme southwestern United States, southward into western Mexico). . . . . 16. *R. intermedia*

17. Fruiting pedicels longer than 12 mm.; leaves pustulate, unlobed, the margin crenate to dentate; seeds 1.5-2 mm. long; petals longer than 6 mm. (Along the Yellowknife Highway near Great Slave Lake of northwestern Canada). . . . . 22. *R. crystallina*

17. Fruiting pedicels shorter than 12 mm. (if longer, the leaves pectinate); leaves without pustules, unlobed or variously sinuate, pectinate, or pinnate-divided; seeds 0.5-1.1 mm. long; petals shorter than 6 mm. except in R. coloradensis (18)

18. Petals shorter than 2.5(3) mm.; style in fruit usually shorter than 0.8(1.2) mm.; anthers globose, 1-1.5 times as long as wide, notched at the apex (fig. 8-A, 2) (transitional in size and shape in R. mexicana) (19)

18. Petals longer than 2.5(2.0) mm.; style in fruit usually longer than 0.8 mm.; anthers elongate, 1.5-3 times as long as wide, apiculate (fig. 8-A, 1) (22)

19. Fruiting pedicels longer than 7 mm.; plants stout, erect, mostly taller than 4 dm.; oldest siliques on lower portion of the terminal raceme. (Long-petaled plants mostly west of the Continental Divide in North America, sparingly elsewhere on the continent north of Mexico). . . . . 20. *R. palustris*

19. Fruiting pedicels shorter than 7 mm.; plants weakly erect to decumbent or prostrate, mostly shorter than 4 dm.; oldest siliques on lower axillary racemes, or siliques nearly equal in age at corresponding points on the terminal and lateral racemes (20)

20. Replum margin minutely hirsute and the valves readily dehiscent, or if replum margin glabrous, the valves not readily dehiscent; pedicels and stem often with slender, short, retrorse, pointed tri-

chomes; petals spreading between the sepals in living plants; pedicels divergent to ascending. (Mostly west of the Continental Divide in the Pacific Northwest of the United States). 8. *R. curvisiliqua*

20. Replum margin and pedicels glabrous; valves readily dehiscent; stems occasionally with a few scattered, but not retrorse, trichomes below; petals erect in living plants; pedicels divergent to recurved (21)

21. Cauline leaves pinnate-divided to pectinate, the lobes less than 4 mm. wide, the margins entire to minutely toothed; style in fruit thick, ca. 0.3-0.4 mm. wide, expanded below the stigma; oldest siliques on lower axillary racemes; seeds ca. 70-100 per silique. (Uplands of northern Mexico, southward in the mountains in Central America to Costa Rica). . . . . 10. *R. mexicana*

21. Cauline leaves unlobed, margin entire, crenate, irregularly serrate to repand, occasionally deeply divided, but lobes more than 4 mm. wide; style in fruit slender, ca. 0.1-0.3 mm. wide, straight throughout; siliques nearly equal in age at corresponding points on the terminal and lateral racemes; seeds ca. 20-80 per silique. (Central Rocky Mountains of the United States at elevations mostly above 9000 ft.). . . 18. *R. curvipes*

22. Stems decumbent to prostrate; leaves and stems with hemispherical vesicular trichomes or elongate, slender, pointed trichomes; basal rosettes wanting in living plants, shallow to deeply sinuate-lobed or pinnatifid (Section Sinuatae) (23)

22. Stems erect; leaves and stems glabrous, or if minutely puberulous, then lobes at base of leaf strongly sagittate; basal rosettes present in young plants; leaves thin, not fleshy, bright, grass green in living plants, unlobed or pinnate-divided to pectinate (28)

23. Petals 6-7.5 mm. long, strongly differentiated into blade and claw; sepals 3.8-5 mm. long. (One collection from southwestern Colorado) . . . . 6. *R. coloradensis*

23. Petals 2-5.5(6) mm. long, slightly or not at all differentiated into blade and claw; sepals 0.7-4.5 mm. long (24)

24. Trichomes vesicular on stems, lower surface of leaves, and sometimes on pedicels and valves, other times these parts of the plant glabrous; siliques short- to elongate-cylindrical or lanceolate with pointed apex, straight to strongly falcate, (4.5)5.7-12.5(16) mm. long, (2.5)4-8 times as long as wide; sepals caducous in fruit; seeds usually more than 35 per silique (25)

24. Trichomes elongate and pointed on stems, lower surface of leaves, and sometimes on pedicels and valves, other times these parts of the plant glabrous; siliques oblong to subglobose with rounded apex, straight, (1.6)2.3-5.5(7) mm. long, 1.3-2.3 times as long as wide; sepals persistent in fruit; seeds usually fewer than 35 per silique (26)

25. Petals (2.5)3.5-5.5(6) mm. long; outer sepals saccate; pedicels divergent to recurved, (3.5)5-11.5(15) mm. long; siliques nearly equal in age at corresponding points on the terminal and lateral racemes. (Widespread throughout the United States mostly west of the Mississippi River). . . . . 4. *R. sinuata*

25. Petals 2.5-3.5 mm. long; outer sepals flat; pedicels divergent to ascending, 3-5.2(6.5) mm. long; oldest siliques on lower axillary racemes. (Uplands of northeastern Mexico in Coahuila and northern Durango, north to the Rio Grande). . . . . 5. *R. ramosa*

26. Siliques glabrous or rarely sparingly pilose; stigma unexpanded in fruit; axillary racemes subumbellate, mostly less than 0.5 dm. long when fully developed. (Sandy shore of Lake Tahoe and vicinity in California and Nevada). . . . . 3. *R. subumbellata*

26. Siliques densely pilose to short-strigose; stigma expanded in fruit; axillary racemes elongate, 0.5-1.5 dm. long when fully developed (27)

27. Siliques densely pilose with elongate trichomes unexpanded at the base; pedicels ascending; sepals and style pilose. (Within the area of the Columbia River basaltic lava [Tertiary age] plateau in northern California, Oregon, and Washington). . . . . 2. *R. columbiae*

27. Siliques densely strigose with short trichomes expanded at the base; pedicels recurved; sepals and style glabrous. (Sandy banks of the Yellowstone River in eastern Montana and northwestern North Dakota). . . . . 1. *R. calycina*

28. Siliques longer than 8 mm. when seeds are formed and mature, equal to or up to 4 times as long as the pedicels; if mature siliques lacking seeds (R. sylvestris), the replum longer than wide (oblong in outline) and the siliques sometimes less than 8 mm. long; style in fruit 0.5-1 mm. long (29)

28. Siliques shorter than 8 mm. when seeds are formed and mature, shorter than the pedicels; if mature siliques lacking seeds (R. austriaca), the replum as wide as long (circular in outline); style in fruit 1-3 mm. long (31)

29. Leaves unlobed, non-auriculate at the base, the margins irregularly serrate; siliques strongly curved upward. (Asian, known from cultivated sites in Chicago and at the New York Botanical Garden). . . . . 29. *R. indica*

29. Leaves pinnately divided to the midrib, auriculate at the base; siliques straight to slightly curved (30)

30. Mature siliques usually lacking seeds; plants clonal from slender spreading underground roots and stems. (European, common in northeastern United States and southeastern Canada, sparingly elsewhere in North America). . . . . 23. *R. sylvestris*

30. Mature siliques with seeds; plants solitary from a vertical taproot. (Uplands of Chihuahua, Mexico, Arizona, and extreme western New Mexico in the United States). . . . . . . 9. *R. microtitis*

31. Siliques globose, 1-1.5 mm. long, as long as wide, often not forming seeds; replum circular in outline; style as long as the silique; cauline leaves unlobed except for clasping, sagittate base. (European, sparingly adventive in northeastern, central, and western United States and central Canada). . . . . 24. *R. austriaca*

31. Siliques elongate-cylindrical, 2-6 mm. long, 2 to 4 times as long as wide, seeds formed; replum oblong to elliptic in outline; style 1/2 to 1/5 as long as the silique; cauline leaves unlobed, laciniate to pectinate and clasping with rounded lobes or non-clasping (32)

    32. Stems hollow; cauline leaves mostly unlobed with margins entire, crenate to serrate, or pectinate; roots often forming at lower leaf nodes; growing in water or along water's edge. (European, sparingly adventive along the St. Lawrence River in Canada and in Maine and Massachusetts). . . . . 25. *R. amphibia*

    32. Stems solid; cauline leaves mostly laciniate-divided, often nearly to the midrib; roots absent from the leaf nodes; growing in drier places. (European, sparingly adventive in coastal eastern United States). . . . . 26. *R. prostrata*

SECTION SINUATAE

Section **Sinuatae** Stuckey, sect. nov.

Perennials; stems decumbent to prostrate, not erect, much branched from below and above, few to numerous from slender spreading underground horizontal roots and stems, forming large clones; basal rosettes wanting; cauline leaves oblong to broadly oblanceolate, shallowly to deeply sinuate, or subpinnatifid to pinnatifid, thick, fleshy, gray green; tips of young sepals and auricles of leaves usually glabrous, except in *R. columbiae* whose sepals and leaves are densely pilose; petals bright sulfur yellow, showy, slightly longer to nearly twice as long as the sepals; anthers elongate, sagittate at a wide base and tapering toward the apex, ca. 1.5-3 times as long as wide, apiculate (fig. 8-A, 1); style usually longer than 1 mm. in fruit.

Herbae perennes; caulibus decumbentibus vel procumbentibus numerosis ramosis; foliis rosulatis absentibus; foliis caulinis vulgo sinuatilobatis crassis; petalis quam sepalis longioribus; antheris elongatis sagittatis apiculatis.

Type species: *Rorippa sinuata* (Nuttall in Torrey et Gray) A. S. Hitchcock. Six species of North American *Rorippa* belong to *Sinuatae*.

1. RORIPPA CALYCINA (Engelmann) Rydberg, Mem. N. Y. Bot. Gard. 1: 175. 1900. [as "*Roripa*"]

Nasturtium calycinum Engelmann in Warren, Prelim. Rep. 156. 1858, reprint 1875; Trans. Am. Philos. Soc. n. s. 12: 184. 1861. ("Sandy bottoms of the Yellowstone river; Fort Sarpy to Fort Union." Lectotype: MONTANA: [Custer Co.]: Sandy bottoms on Yellowstone [River] near Fort Sarpy [Fort Alexander Sarpie was at about the present location of Sheffield], Jul 1854, *F. V. Hayden s.n.*, MO! Photo at MICH! OS! Isolectotypes, GH! NY!)

Nasturtium sinuatum Nuttall in Torrey et Gray var. *calycinum* (Engelmann) Watson in Gray, Syn. Fl. N. Am. 1: 147. 1895.

Radicula calycina (Engelmann) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Stems 1-4 dm. tall, moderately to densely hirsute with simple slender trichomes slightly expanded at the base and pointed at the apex; middle cauline leaves sessile, auriculate and partly clasping the stem, oblong to oblanceolate, 2.5-5 cm. long, 0.5-1 cm. wide, shallow to strongly sinuate with the sinuses reaching about half-way to the midrib, both surfaces hirsute, especially on the midrib, the apex acute to obtuse; racemes terminal and axillary, ca. 0.5-1.5 dm. long, forming simultaneously after stem elongation, the siliques therefore nearly equal in age at corresponding points on the racemes, or racemes lateral, developing during stem elongation in the axils of the lower leaves and progressing upward, without the development of a true terminal raceme, the oldest siliques therefore on the lower axillary racemes; pedicels 3.5-6.5 mm. long, glabrous to sparingly hirsute, ca. 1.5-2 times as long as the siliques, strongly recurved, often in the same direction and giving the siliques the appearance of being borne unilaterally; sepals ovate to lanceolate, 2.1-3.1 mm. long, 0.7-1.2 mm. wide, saccate, persistent in fruit, glabrous; petals oblong to oblanceolate, (2)2.5-3.7 mm. long, 0.6-1.3 mm. wide, up to 1 mm. longer than the sepals; siliques globose to subglobose, 2.3-3.4 mm. long, 1.2-2.3 mm. wide, ca. 1.3-2 times as long as wide, the valves densely strigose with very short trichomes expanded at the base and pointed at the apex; replum elliptic in outline, the margin convex and hirsute; style 1-2.2 mm. long, ca. 0.1-0.2 mm. wide in fruit, straight throughout, abruptly attached or somewhat gradually merging into the rounded silique apex, glabrous; stigma expanded in fruit; seeds regularly cordiform, ca. 0.7-0.8 mm. long, ca. 20 per silique, the surface prominently colliculate; flowering and fruiting May-July (August-September).

Rorippa calycina is unique in this section in having globose to subglobose siliques densely covered with very short sharp-pointed trichomes expanded at the base, a very long, slender, glabrous style in fruit, glabrous persistent sepals, strongly recurved pedicels, and shallowly sinuate-lobed entire leaves. It is most closely allied to *R. columbiae.*

Rorippa calycina has long been confused in the literature. Piper (1906) reported it from Washington, Oregon, and Montana. The collection he cited, "Sandberg & Leiberg in 1892," is *R. columbiae.* Wooton and Standley (1915) gave the range as Washington and Oregon to Colorado and northern New Mexico, citing, for the latter state, several localities. Plants labeled by them as *R. calycina* from these localities possess prominent hemispherical vesicular trichomes on the fruit; they are *R. sinuata.* The confusion has come about through equating the vesicular trichomes on the siliques of *R. sinuata* from New Mexico and Colorado with the very short-pointed, thick-based, simple hairs on fruits of *R. calycina.* Reports by Daniels (1911) and Rydberg (1906) from Colorado and by Fosberg (1940) from New Mexico are similarly *R. sinuata.*

DISTRIBUTION: Map 20-A.

Known from sandy banks of the Yellowstone River in eastern Montana and at its mouth in northwestern North Dakota, *R. calycina* was first collected by Hayden during 1854-55. These specimens were used by Engelmann when he described the species, giving, as the source localities, "sandy bottoms of the Yellowstone river, Fort Sarpy to Fort Union." The latter is at the mouth of the Yellowstone River in Mackenzie County, North Dakota. Ft. Sarpy was located on the Yellowstone above the mouth of the Tongue River approximately where Sheffield in western Custer County, Montana, is today. I have chosen as lectotype the specimen from Ft. Sarpy because it is the most complete, having mature fruits and racemes. Since Hayden, only one other botanist, Blankinship, is known to have collected this species in the Yellowstone River valley. On the label of a specimen at MO, Blankinship wrote "Custer, Montana (type locality)." This collection came from either the town of Custer (farther up the Yellowstone from Sheffield) or from approximately the type locality, if Blankinship meant Custer County.

Mulligan and Porsild (1966) reported *R. calycina* on a delta of the Anderson River in the Northwest Territories, about 2500 miles north of the species' range in Montana and North Dakota. They seem to suggest that, at the Anderson River, *R. calycina* is probably an introduction rather than a preglacial relic or a remnant of a postglacial prairie migration.

2. RORIPPA COLUMBIAE Suksdorf ex Howell, Fl. N. W. Am. 1: 40. 1897. [as "*Roripa*"]. ("*Nasturtium Columbiae Suksdorf in Herb. distr. 952.*" Holotype: WASHINGTON: Klickitat Co.: Low gravelly bank of the Columbia River near Bingen, 21 Sep, 14 Oct 1890, *W. N. Suksdorf 952*, presumably at ORE. Isotypes, GH! MO! MSC! US! WS! Photo of MO specimen at MICH! OS!)

Nasturtium sinuatum Nuttall in Torrey et Gray var. *columbiae* Suksdorf ex Robinson in Gray, Syn. Fl. N. Am. 1: 147. 1895. [Based on *Suksdorf 952*]

Nasturtium sinuatum Nuttall in Torrey et Gray var. *pubescens* Watson in Gray, Syn. Fl. N. Am. 1: 147. 1895. (Holotype: OREGON: [Multnomah Co.]: Sauvie's Island, 1 Jun 1884, *Joseph Howell s.n.*, GH!)

Roripa [sic] *sinuata* (Nuttall in Torrey et Gray) A. S. Hitchcock var. *pubesens* (Watson in Gray) Howell, Fl. N. W. Am. 1: 40. 1897.

Nasturtium columbiae Suksdorf ex Howell, Fl. N. W. Am. 1: 40. 1897, pro syn.; Suksdorf, Deutsch. Bot. Monatsschr. 16: 211. 1898. (Holotype: *Suksdorf 952*, WS!)

Radicula columbiae (Howell) Greene, Leafl. Bot. Obs. & Crit. 1: 114. 1905.

Rorippa calycina (Engelmann in Warren) Rydberg var. *columbiae* (Suksdorf ex Robinson in Gray) Rollins, Contr. Dudley Herb. 3: 176. 1941.

Stems 1-3(4) dm. tall, densely pilose with simple, very slender trichomes nearly equal in diameter throughout and pointed at the apex; middle cauline leaves sessile to short-petiolate, auriculate and partly clasping the stem to non-auriculate and non-clasping, oblong to oblanceolate, 2.5-5 cm. long, 0.5-1 cm. wide, deeply sinuate or pinnatifid with the sinuses often nearly reaching the midrib, both surfaces pilose, the lobes mostly oblong to elliptic with margins entire to minutely toothed, the apex acute to obtuse; racemes terminal and axillary, ca. 0.5-1.5 dm. long, forming simultaneously after stem elongation, the siliques therefore nearly equal in age at corresponding points on the racemes, or rarely racemes lateral, developing during stem elongation in the axils of the lower leaves and progressing upward, without the development of a true terminal raceme, the oldest siliques therefore on the lower axillary racemes; pedicels (2.5)4.0-9.8(11.5) mm. long, densely pilose, ca. 1-2.5 times as long as the siliques, ascending in two or more directions and not giving the siliques the appearance of being borne unilaterally; sepals ovate to oblong, 2.1-3.5 mm. long, 0.7-1.5 mm. wide, mostly flat, persistent in fruit, densely pilose; petals oblong-oblanceolate to spatulate, 2.7-4.1 mm. long, 0.8-1-8 mm. wide, up to 1 mm. longer than the sepals; siliques oblong to subglobose, (1.6)2.5-5.4(7) mm. long, (0.9)1.8-2.8(3.4) mm. wide, ca. 1.5-2.2 times as long as wide, the valves densely pilose with simple, very slender trichomes nearly equal in diameter throughout except pointed at the apex; replum oblong to elliptic in outline, the margin convex and pilose; style 0.7-3.1 mm. long, ca. 0.3-0.4 mm. wide in fruit, straight throughout, abruptly attached or somewhat gradually merging into the rounded silique apex, densely pilose; stigma strongly expanded in fruit; seeds regularly cordiform, 0.8-0.9 mm. long, ca. 20-30 per silique, the surface prominently colliculate; flowering and fruiting June-October.

ILLUSTRATIONS: Abrams (1944, p. 281, fig. 2024); Hitchcock & Cronquist (1964, p. 538), as *R. calycina* var. *columbiae*.

Rorippa columbiae is distinct from other North American *Rorippa* in having the stems, both leaf surfaces, pedicels, sepals, siliques, and styles densely pilose. In addition, it is distinguished from its close relative, *R. calycina*, by the deeply pinnatifid lobes of the leaves with minutely toothed margins, more oblong slightly thicker siliques on ascending pedicels, and well developed expanded stigma. From *R. subumbellata*, also a close relative, it differs in having more elongate racemes, densely pilose siliques, usually longer pilose style, and expanded stigma.

Plants with these characters were first carefully observed by Suksdorf. His collections, from "low gravelly bank of the Columbia River near Bingen," were labeled "952 Nasturtium Columbiae n. sp." and were distributed to a number of botanists. Robinson, who edited Watson's (1895) treatment of *Rorippa* in Gray's *Synoptical Flora of North America*, first gave formal recognition to this taxon, publishing "Nasturtium sinuatum Nutt. var. Columbiae, Suksdorf (as spec.)" and citing "Suksdorf, distr. 952." Howell (1897), unaware of Robinson's work, described the taxon as a species under the name *Roripa* [sic] *columbiae*, citing the Suksdorf collection. Howell probably had one of Suksdorf's specimens, and therefore presumably the holotype is in Howell's herbarium at ORE. Suksdorf (1898) finally published the name *Nasturtium columbiae*, but since he cited both Robinson's and Howell's names, his name is superfluous.

The only difference between Watson's (1895) *Nasturtium sinuatum* var. *pubescens* and *R. columbiae* is the slightly longer pedicels of the former.

Abrams (1944), Munz and Keck (1959), and Hitchcock and Cronquist (1964) accurately describe *R. columbiae*; however the latter two works follow Rollins in maintaining it as a variety of *R. calycina*. Peck's (1961) report that *R. columbiae* extended to Montana, Nebraska, and New Mexico is a case of confusing it with *R. calycina* or with plants of *R. sinuata* having fruits with vesicular trichomes. The report of *Radicula columbiae* by Winter (1936) from Scotts Bluff County, Nebraska, was based on a specimen (duplicate seen at NY and US) of *R. sinuata* with vesicular trichomes on the fruits.

DISTRIBUTION: Map 1-A; 20-B.

The distribution of *R. columbiae* appears to be related to the Columbia River lava plateau of Tertiary age. This plateau, one of the largest basaltic lava fields ever formed, was built up by successive eruptions that reached great intensity about the Miocene (Hussey, 1947). Map 1-A shows the distribution of *R. columbiae* to lie in the area covered by this soil formation. That the distribution of *R. columbiae* shows relationship with lava soils is suggested from label data of a collection from Siskiyou County, California, "lava slopes of lava beds," (*Thompson 13148*, GH, MO, NY, PH, RSA, US) and from Klamath County, Oregon, "heavy-soiled playa," (*Constance, Molseed, Weiler 3680*, FSU, GH, MO, MSC, RSA, US, WIS).

In map 1-A, circles represent pre-1905, and dots represent post-1905 specimens. Only in the Klamath Lake region of Oregon and California has this species been found recently. I propose later in this paper that *R. columbiae* is an isolated relic probably once more abundant and widespread than today. I think it may have decreased its range even in the past 60 years, as the map data reveal. In 1963, my attempt to rediscover *R. columbiae* and *R. sinuata* in the type localities ended in failure after a 4 days' search along the Columbia River from The Dalles to Sauvies Island.

3. RORIPPA SUBUMBELLATA Rollins, Contr. Dudley Herb. 3: 177. 1941. (Holotype: CALIFORNIA: El Dorado Co.: Meek's Bay, Lake Tahoe, 6100 ft, 29 Jul 1919, *A. A. Heller 13329a*, GH! Isotypes, MO! NY! US! WIS! Photo of MO specimen at MICH! OS!)

Stems 0.5-1.5(2.8) dm. tall, glabrous to sparingly pilose with simple, very slender trichomes nearly equal in diameter throughout and pointed at the apex; middle cauline leaves sessile to very short petiolate, non-auriculate, oblong to broadly oblanceolate, 1-3 cm. long, 0.3-1 cm. wide, sinuate to subpinnatifid, upper surface sparingly pilose to glabrous, lower surface moderately pilose, the lobes mostly oblong to elliptic with margins usually entire, the apex mostly obtuse; racemes terminal and axillary, up to 0.5 dm. long, forming simultaneously after stem elongation, the siliques therefore nearly equal in age at corresponding points on the racemes; pedicels

4.1-9 mm. long, pilose, ca. 1-2 times as long as the siliques, ascending in 2 or more directions; sepals ovate to oblong, 2.3-2.8 mm. long, 0.9-1.5 mm. wide, flat, persistent in fruit, glabrous to sparingly pilose; petals oblong-oblanceolate to spatulate, 2.7-3.4 mm. long, 1-1.5 mm. wide, up to 1 mm. longer than the sepals; siliques oblong to subglobose, 3.5-5.5 mm. long, 2-3(3.7) mm. wide, ca. 1.5-2.3 times as long as wide, the valves glabrous to very sparingly pilose; replum oblong to elliptic in outline, the margin convex and glabrous; style 0.7-1.5 mm. long, 0.3-0.4 mm. wide in fruit, straight throughout, abruptly attached or somewhat gradually merging into the rounded silique apex, glabrous; stigma unexpanded in fruit; seeds somewhat angularly cordiform, ca. 0.9-1.1 mm. long, ca. 20-30 per silique, the surface very prominently colliculate; flowering and fruiting June-September.

ILLUSTRATION: Rollins (1941, p. 184, pl. XLVI, fig. 2)

Rorippa subumbellata is most closely allied to *R. columbiae* and is distinguished from it in having glabrous to sparingly pilose siliques, short subumbellate racemes, an unexpanded stigma, usually shorter, glabrous styles, and larger, very prominently colliculate seeds. The leaves appear more fleshy and the stems more stiff.

Before Rollins' recognition of *R. subumbellata*, specimens passed under the name *R. sinuata* or its synonyms as indicated from descriptions and localities cited (e.g., Greene, 1891; Jepson, 1925, 1936). Mason (1957), Munz and Keck (1959), and Rollins (1941) considered it endemic to shores of Lake Tahoe. Two old collections in Greene's herbarium (ND-G) extend the distribution to Truckee and Tallac Lake.

Rollins recollected specimens of *R. subumbellata* at the type locality in 1942. I did not find it there in 1963 but did find two colonies on the beach at Bliss Memorial Park. Here this rare species survives in shifting sand, enduring much abuse from the tramping feet of swimmers and sun bathers.

DISTRIBUTION: Map 1-B; 20-C.

4. RORIPPA SINUATA (Nuttall in Torrey et Gray) A. S. Hitchcock, Spring Fl. Manhattan 18. 1894.

Nasturtium sinuatum Nuttall in Torrey et Gray, Fl. N. Am. 1: 73. 1838. ("Banks of the Oregon [River] and its tributaries; also in Arkansas." Lectotype: OREGON or WASHINGTON: [county unknown]: Columbia river & Arkansas, [ca. 1834, *fide* Pennell (Bartonia 18: 36. 1936), *Thomas Nuttall s.n.*], BM. Photo no. BM 2124, GH! [The specimens were originally labeled "Nasturtium *sinuatum" by Nuttall.] Isolectotype, PH!)

Nasturtium trachycarpum Gray, Bull. U. S. Geol. & Geog. Surv. Terr. 2: 233. 1876. ("Southwestern Colorado," [also, "S. W. Colorado, on the San Juan [River], &c.," Gray (1876). This reference is given in the literature cited.] Holotype: COLORADO: [Probably Archuleta Co.]: S. W. Colorado, 1871, *T. S. Brandegee 1180*, GH! Isotype, [with printed label, "Hayden's U. S. Geological Survey, 1875"] MO! Photo at MICH! OS!)

Roripa [sic] *trachycarpa* (Gray) Greene, Pittonia 3: 96. 1896.
Radicula sinuata (Nuttall in Torrey et Gray) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.
Radicula trachycarpa (Gray) Rydberg, Bull. Torrey Club 39: 322. 1912.

Stems 1-4(5) dm. tall, sparsely to densely pubescent with hemispherical vesicular trichomes; middle cauline leaves sessile, auriculate and partly clasping the stem to non-auriculate and non-clasping, oblong to oblanceolate (1.6)2.8-6(8.5) cm. long, 0.4-1.3(1.8) cm. wide, shallow to deeply sinuate, pinnatifid to subpinnatifid nearly to the midrib, the lower surface sparsely to densely covered with vesicular trichomes on the midrib, upper surface glabrous, the lobes oblong to elliptic with margins entire to minutely toothed, the apex acute to pointed; racemes terminal and axillary, ca. 1-2.5 dm. long, forming simultaneously or the axillary ones forming somewhat earlier, the siliques therefore nearly equal in age at corresponding points on the racemes; pedicels (3.5)5-11.5(15) mm. long, glabrous, or sparsely to densely covered with vesicular trichomes, recurved to ascending or often divergent at right angles to the raceme axis and then becoming recurved or ascending near the distal end; sepals oblong, ovate to lanceolate, 2.7-4.5 mm. long, 1.1-1.7 mm. wide, strongly saccate, caducous in fruit, glabrous or with a few vesicular trichomes on the lower portion of the dorsal surface; petals oblong, oblanceolate, or narrowly spatulate, (2.5)3.5-5.5(6) mm. long, 1.4-2.2 mm. wide, up to 3 mm. longer than the sepals; siliques short- to elongate-cylindrical, oblong, to somewhat lanceolate, obtuse below and slightly to strongly falcate toward the raceme axis, (4.5)5.7-12.5(16) mm. long, 1-1.8(2.5) mm. wide, ca. (2.5)4-8 times as long as wide, ca. (0.3)0.6-2 times as long as the pedicels, the valves glabrous or rough with minute or prominent hemispherical vesicular trichomes over the entire surface or on the edges only; replum linear to narrowly oblong in outline, the margin straight to slightly concave, and glabrous or sparingly with vesicular trichomes; style (0.5) 1-2(3.4) mm. long, ca. 0.3-0.5 mm. wide in fruit, tapering to the apex, gradually merging into the pointed silique apex, glabrous; stigma unexpanded when the siliques produce mature seeds, expanded when seeds fail to mature; seeds sharp, angularly cordiform, ca. 0.7-0.9 mm. long, ca. 0.5-0.6 mm. wide, longer than wide, ca. (25)40-80(100) per silique, the surface finely colliculate; flowering and fruiting April-October.

ILLUSTRATIONS: Abrams (1944, p. 277, fig. 2023); Britton & Brown 1897, p. 124, fig. 1714; 1913, p. 160, fig. 2027); Fassett (1940, p. 232, fig. 16); Fernald (1950, p. 715, fig. 1108), siliques and leaves; Gleason (1952, p. 239); Hitchcock & Cronquist (1964, p. 540); Steyermark (1963, p. 759, pl. 185, no. 3).

Rorippa sinuata is a distinct but variable species, especially in length of fruits and pedicels. The distinctive siliques are short- to elongate-cylindric or lanceolate, nearly straight to strongly falcate, and usually on long pedicels arising at right angles from the raceme axis but then bending up or down. The unusual trichomes are somewhat vesicular and hemispherical rather than elongated and pointed. On dried specimens they often appear flat and scale-like because they are collapsed. They are rather sparse on stems and on the midrib of the lower leaf surface in specimens mostly from the plains states. Increase in trichome abundance and density occurs on material primarily from mountainous regions of western United States. The silique valves vary from glabrous or sparsely covered with trichomes (often only along the edges) to entirely and densely covered with them, as on siliques of a specimen collected in southwestern Colorado in 1875 by Brandegee and used by Gray (1876) as the basis of his *N. trachycarpum*. Pubescent pods occur on most specimens from Arizona and New Mexico, from El Paso in Texas, and from Wyoming except the one seen from Cheyenne. Fruits with glabrous valves are found in the Texas panhandle, Oklahoma, Arkansas, Minnesota, and Montana. Plants with a complete spectrum of trichome variation occur in Illinois, Iowa, Missouri, Nebraska, Kansas, Colorado, and the Great Basin. Plants from the Great Basin are mostly glabrous but a few have indications of trichomes. Although there is some geographic segregation of the two valve-surface types, there is considerable overlap through the central plains states. There is also considerable variation in abundance, distribution, and development of these trichomes on plants throughout the species, sometimes even on the same plant. Although Great Basin plants tend to have smaller petals (ca. 2.5-4.0 mm.), often shorter siliques and pedicels, and a more prominently colliculate seed, I find no feature correlating with the trichome variation pattern. Two separate species or two varieties of one species should therefore not be maintained. I agree with Rollins (1961) that these peculiar vesicular trichomes alone are not a basis for taxonomic separation.

With regard to typification of *R. sinuata*, I agree with Rollins (1961).

DISTRIBUTION: Map 2; 20-D.

Rorippa sinuata is most abundant in the Rocky Mountains of southern Wyoming, Colorado, and northern New Mexico, extending eastward onto the plains in the Texas panhandle, western Oklahoma, Nebraska, and South Dakota where it is common. East of longitude 100° the localities are mostly along major rivers, such as the Arkansas, Kansas, Missouri, and Mississippi. Southward the plants grow along the Rio Grande in New Mexico and the Little Colorado in Arizona. Additional stations in these two states are in wet places in the mountains. The species is absent from Utah and then recurs in the Humboldt and Truckee river valleys of Nevada as well as in a few other localities in Nevada and California. To the northwest it is almost entirely confined to the banks of the Snake and Columbia rivers. It seems plausible that the species had its origin in the Colorado Rocky Mountains. In addition to being frequent there, the plants vary much in pedicel length, fruit shape and length, and trichome distribution on the fruit. Outward from this region the plants are often found along or in the valleys of the major river systems. I believe the distribution pattern of *R. sinuata* has come about primarily by migration down major rivers. Factors favoring such migrations are discussed later, but first it is important to determine when this migration may have occurred and to establish which parts of the range have come about by natural means and which by artificial.

Certainly its spread into western Canada, eastern South Dakota, Minnesota, and Wisconsin occurred since retreat of the Wisconsin glacier. Specimens collected before 1870 are significant in that many of them come from localities on the present edge of the species' range. Of particular importance are Nuttall's collections in Arkansas and along the Columbia River. *Rorippa sinuata* was probably as widely distributed west of the Mississippi then as it is now. Most scattered outlying occurrences presumably came about naturally before European man became established in western United States.

East of 97° longitude, the plants are found primarily along major rivers. Those along the Minnesota and upper Mississippi rivers in Minnesota and Wisconsin are disjunct from those in South Dakota and western Iowa. Patman and Iltis (1961) stated that the Wisconsin plants were introduced from western United States, implying, perhaps, a rather recent introduction. *Rorippa sinuata* may well be introduced into Wisconsin, but it is interesting to note when this introduction may have occurred. Parry (1852) collected *R. sinuata* along the lower St. Peter's [Minnesota] River in 1848—before much settlement by European man there. The two collections from northeastern Illinois ("R.R. track, Naperville"; "on ballast, Palos Park") are certainly introductions. Besides these collections, the species is confined, in Illinois, to the Mississippi River except for one collection from Greenfield and those mapped by Jones and Fuller (1955), for which I have not seen specimens. *Rorippa sinuata* occurs in Iowa along the western edge of the Missouri River valley, plus one collection at Cordova in the south central part of the state. In Arkansas the species has been found on the Arkansas River, in addition to a collection from Corning in the northeastern corner. Although this may be of no significance, the three towns mentioned above are served by railroads, and the colonies may have become established through man's activity. The collection from Daviess County in northwestern Missouri, however, came from an area not now served by a railroad.

North and east of Illinois there have been a few reports for *R. sinuata*. Walpole (1927) listed it from Marquette County, Michigan, but that collection is *R. sylvestris*. Wilson (1906) stated that a colony persisted for 15 years along a railroad west of Greencastle, Indiana. In the absence of a verifying specimen, Deam (1940) excluded the species from the Indiana flora. I have not seen the specimen cited from Maryland by Reed (Phytologia 10: 345. 1964). In summary, it appears that *R. sinuata*, native to the southern Rocky Mountains and the Great Plains, has migrated down major rivers to the east, south, and west. Its present distribution has come about by this migration, rather than through man's interference except for those plants in Maryland, the Chicago area, and possibly some of the localities east of 97° longitude but not on a major river.

Rorippa sinuata is perennial. Once a plant is established, young buds and vegetative shoots may grow from the roots and a massive clone may be formed if the soil is wet and growing conditions are favorable. If drier conditions develop, the roots remain alive. With a return to more favorable conditions, the plants may then grow and continue to spread. In the greenhouse, once the roots penetrate the cinders on the bench, new plants reappear from the old roots long after the potted plants have been removed. Stems of *R. sinuata*, placed in water, grow roots (two at each node) within a week. When transferred to soil, the stems grow, send out branches, and form new colonies.

Rorippa sinuata is well adapted to a wide variety of soil types and habitats. Loose sandy, gravelly, or alluvial wet soil is ideal for spread of the roots. Lake shores and stream banks are frequent habitats. The perennial roots may penetrate and survive in much drier soils, or the clone may continue to live if the water level is lowered. Data on herbarium labels indicate that plants were found in sandy clay, saline, alkaline, granitic, sandstone, and heavy black loam soils and in disturbed sites such as parking lots, roadsides, railroad banks, ballast, and buffalo wallows. I collected *R. sinuata* in very wet soil along a Colorado irrigation ditch, a wet roadside in western Iowa (where Isely collected it 11 years earlier), and at the margin of a dry corn field in Colorado. The ability of the roots to rejuvenate under favorable (wet) conditions long after aerial parts of the plants have been removed, the ability of the stems to grow roots at nodes when kept very damp or in water, and the ability of the plants to persist for years by forming perennial colonies are adaptations aiding *R. sinuata* in its dispersal down the major river systems in western United States as well as in its establishment in man-disturbed sites.

Of native North American *Rorippa*, *R. sinuata* best shows downriver dispersal. When plants of perennial species get rafted downstream, take root, and become established, they have a mechanism for survival for several years. In contrast, many annuals show less apparent migration down river; their survival mechanism is, by comparison, poor. If an individual of an annual (e.g., *R. tenerrima* or *R. truncata*) becomes established on an exposed open bank it may persist a few years; but should the water level become lower, the soil drier, and the site not disturbed for several years, other plants move in and the annual can no longer compete. On the other hand, the perennial can withstand for a longer time some drying and competition. The differences are reflected in collections made over 100 or more years in places to which these plants have migrated. Chances are greater that plants of perennial species will be collected. Thus, when one compares distributions of species that show downriver migration, e.g., *R. sinuata*, with *R. tenerrima* or *R. truncata*, the perennial one, *R. sinuata*, is more common than the annual one (compare map 2 with map 4 or map 11). The introduced perennial *R. sylvestris* (Stuckey, 1966b), which spreads like *R. sinuata*, is more widely dispersed in the eastern half of the continent than the introduced annual *R. palustris* var. *palustris*, which is confined to places where it apparently was originally introduced along the east coast.

Not only is the wide distribution of *R. sinuata* indicative of success in becoming established in various habitats, but it also grows in the dry Great Plains, a region where annuals occur very sporadically and that receives little rainfall, usually less than 16 inches. The correlation is shown well by the distribution of *R. sinuata* (map 1) and that of *R. curvipes*, an annual (map 14). *Rorippa curvipes* is virtually confined to the Rocky Mountains in areas of over 16 inches of rainfall a year. *Rorippa palustris* var. *fernaldiana*, annual, is also absent from the dry prairie region of western Texas, Oklahoma, and Kansas.

5. RORIPPA RAMOSA Rollins, Rhodora 63: 4. 1961. (Holotype: MEXICO: DURANGO: In a dry arroyo, 3 miles northwest of Ceballos, 4 May 1959, *D. S. Correll, I. M. Johnston 21449*, GH! Isotype, LL., *fide* Rollins, 1961.)

Stems 1-5 dm. tall, sparsely pubescent with hemispherical vesicular trichomes; middle cauline leaves sessile, auriculate and partly clasping the stem, oblong to broadly oblanceolate (2)3-5 cm. long, 0.5-1.2 cm. wide, deeply sinuate, pinnatifid to subpinnatifid, the lower surface with vesicular trichomes on the midrib, upper surface glabrous, the lobes oblong to elliptic with margins entire to minutely toothed, the apex acute to pointed; racemes lateral, ca. 0.5-1(1.7) dm. long, developing somewhat after or during stem elongation in the axils of the lower leaves and progressing upward, without the formation of a true terminal raceme, the oldest siliques therefore on the lower axillary racemes; pedicels 3-5.2(6.5) mm. long, divergent to ascending, sparsely covered with vesicular trichomes; sepals oblong, 2-2.5 mm. long, 0.7-1.3 mm. wide, flat, caducous in fruit, glabrous or with a few vesicular trichomes on the lower portion of the dorsal surface; petals spatulate, 2.5-3.5 mm. long, 0.7-1.3 mm. wide, up to 2 mm. longer than the sepals; siliques oblong to lanceolate, slightly curved inward, obtuse below and tapering toward the apex, 5.5-9.8(11) mm. long, ca. 2-3 mm. wide, ca. 2.5-4 times as long as wide, ca. 1.5-2 times as long as the pedicels, the valves glabrous to sparingly rough with hemispherical vesicular trichomes except along the edges where the trichomes are very dense; replum linear to oblong in outline, the margin straight to slightly concave and sparingly with vesicular trichomes; style 1-2 mm. long, ca. 0.3-0.5 mm. wide in fruit, tapering to the apex, merging into the silique apex, glabrous; stigma unexpanded to slightly expanded in fruit; seeds angularly cordiform, 0.7-0.8(1) mm. long, 0.8-1.2(1.5) mm. wide, ca. 40-80 per silique, the surface colliculate; flowering and fruiting March-May.

ILLUSTRATION: Rollins (1961, p. 5, fig. A-C)

I agree with Rollins (1961) that *R. ramosa* and *R. sinuata* are related in their sinuate-pinnatifid leaves, vesicular trichomes, caducous sepals, elongate-cylindrical fruits tapering toward the apex and merging into the style, and unexpanded stigma. Distinguishing characters of *R. ramosa*, in addition to those in the key, are a slightly thicker, more lanceolate silique, a tendency toward shorter styles, usually shorter axillary racemes, and less angular, more prominently colliculate seeds wider than long.

Rollins (1961) described *R. ramosa* as a densely leafy, highly ramified, flat, nearly circular plant, with numerous stems at the summit of a taproot, the plants growing in colonies with individuals interconnected underground, with stems single or at most with three or four emergences at a given locus. Although *R. sinuata* may behave in this manner, I have seen many herbarium specimens with numerous stems from a common base. Living plants in the greenhouse show the latter feature, especially when pot-bound. Whitehouse noted "spreading by runners" on a collection label. Although I did not study wild plants, it appears that *R. ramosa* may also spread in a fashion similar to *R. sinuata*, and that the differences in growth habit and clonal formation are not as real as they appear.

DISTRIBUTION: Map 3; 20-E.

Rorippa ramosa is geographically isolated from *R. sinuata* although the species may occur together along the Rio Grande.

6. RORIPPA **coloradensis** Stuckey, sp. nov. (Holotype: COLORADO: [Probably Alamosa Co.]: S. W. Colorado, [probably in the vicinity of the lakes of San Luis valley], 1875, *T. S. Brandegee 1069* PH! Photo at MICH! Fig. 1.)

Stem slender, strigose with elongate pointed often retrorse trichomes; cauline leaves petiolate, non-auriculate, oblong to broadly oblanceolate, 2.3-3 mm. long, 0.5-1 mm. wide, shallowly to somewhat deeply sinuate-lobed, strigose with elongate pointed trichomes on lower surface, the upper surface nearly glabrous, leaf apex obtuse, the margins entire to very slightly toothed; buds 3.5-5 mm. long, 2.5-3 mm. wide; sepals oblong to oblanceolate, 3.8-5 mm. long, 1.8-2.5 mm. wide, strongly saccate, glabrous or with a few short trichomes at the apex; petals broadly spatulate, strongly differentiated into blade and claw, 6-7.5 mm. long, 2.2-2.5 mm. wide, up to 2.5 mm. longer than the sepals; siliques immature but one (at the time the petals have fallen) ca. 2 mm. long, 0.6 mm. wide, covered with delicate slender pointed trichomes; mature fruit not known.

Herba perennis; caulibus gracilibus strigosis; foliis petiolatis non auriculatis oblongis vel late oblanceolatis 2.3-3 cm. longis, 0.5-1 cm. latis sinuatilobatis strigosis; sepalis oblongis vel oblanceolatis 3.8-5 mm. longis, 1.8-2.5 mm. latis saccatis; petalis late spathulatis 6-7.5 mm. longis, 2.2-2.5 mm. latis.

ILLUSTRATION: Fig. 1.

The extremely large buds and flowers with spatulate petals strongly differentiated into blade and claw make this species distinctive from others in *Sinuatae* and from most other *Rorippa*. It is closely related to *R. calycina* in leaf and trichome characters, but the undeveloped fruits are rather elongated; fully developed, they apparently would resemble those of *R. sinuata* or *R. ramosa*, thereby bridging the two evolutionary lines in *Sinuatae*.

The one collection known consists of three small plants obtained by Bran-

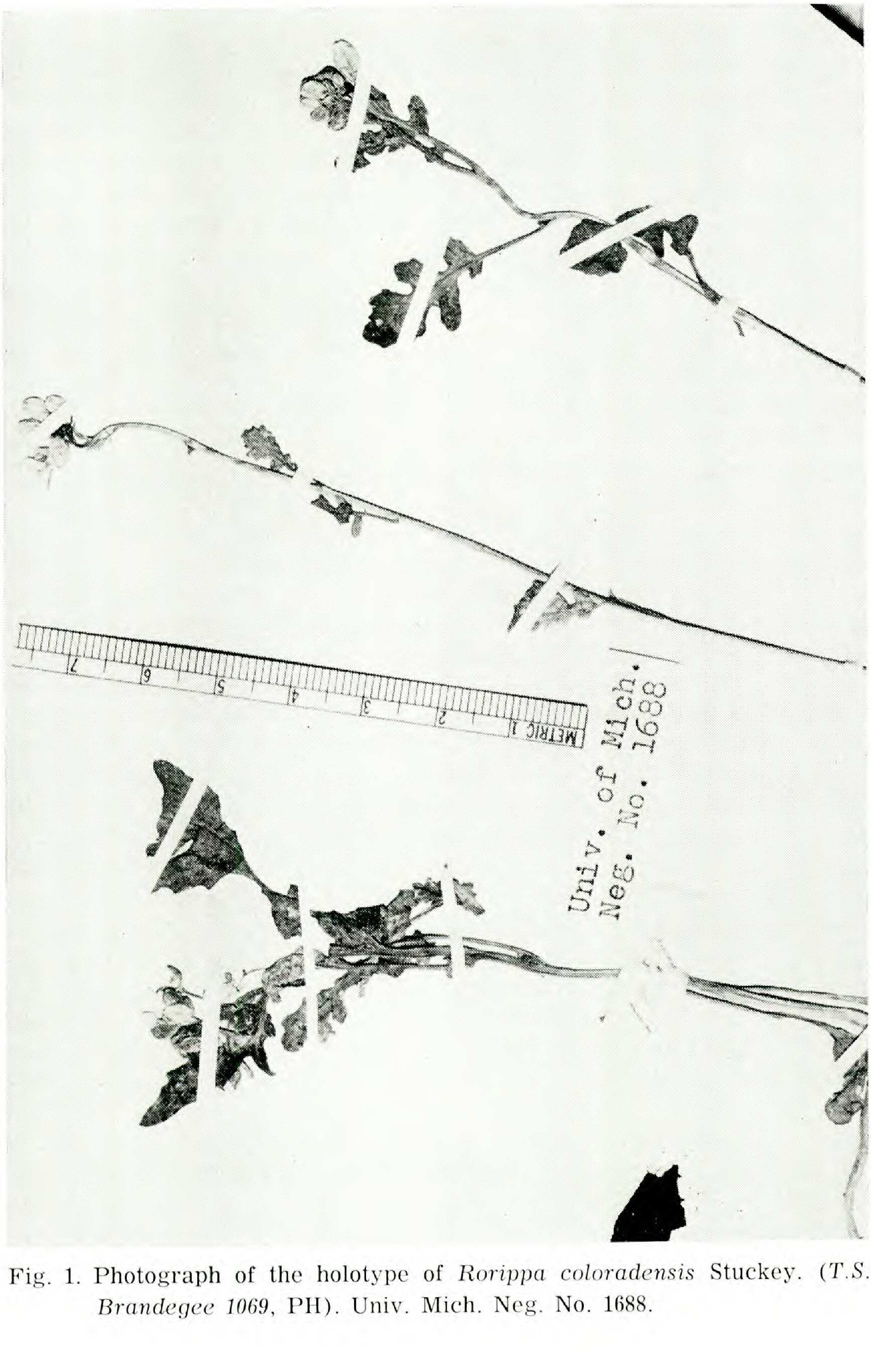


Fig. 1. Photograph of the holotype of *Rorippa coloradensis* Stuckey. (*T.S. Brandegee 1069*, PH). Univ. Mich. Neg. No. 1688.

degee during his southwestern Colorado expedition under F. V. Hayden in 1875. The collection (PH) is identified as *Nasturtium trachycarpum* Gr[ay], and bears no additional information except the number 1180 on the label, and the number 1069 glued to one of the plants. The number 1180 is also on both the holotype (GH) and an isotype (MO) of *N. trachycarpum* (=*R. sinuata*), also Brandegee specimens made on the same expedition. The number 1069 suggests this is really a separate collection rather than that the type material of *N. trachycarpum* is heterogeneous.

According to Ewan (1942) "no field notebooks appear to have been kept" by Brandegee, and no collections appear to have been numbered by him, except some southwestern Colorado specimens; numbers may have been assigned by Porter or Redfield, who supplied printed labels for the survey collections. Printed labels on two sheets of *Rorippa* from this survey in the Redfield Herbarium at MO are numbered 1068 and 1180 opposite Brandegee's name, with 1068 in parentheses. These must be Brandegee's numbers. The number 4268 or 4267 is written in the upper left hand corner, and these (not the numbers 1068 and 1180) are probably the numbers newly assigned by Redfield or Porter. They are consecutive, suggesting that the new numbers were given after the plants were taxonomically grouped. Plants of Brandegee's 1069 were apparently considered the same as his 1180, and distributed under the name *N. trachycarpum.* Collection 1068 was kept separate and labeled *N. sinuatum.* Duplicates of collection 1069 have not been found.

To determine the localities for Brandegee's Colorado expedition specimens is a problem because they are often labeled merely "S. W. Colorado." Ewan (1942) reported that Brandegee's Colorado collections of 1875 came from the San Juan, Rio Mancos, and Rio la Plata drainages. *Nasturtium trachycarpum* (1180) came from the San Juan River, according to Gray (1876). In the report of Brandegee's itinerary, Ewan gives only the localities for the 1875 trip and the county in which the plants were collected. No dates or specimen numbers are listed; thus localities cannot be correlated with specimens. If we consider these apparent Brandegee numbers as field numbers perhaps assigned consecutively as plants were obtained, and because 1068 came from "Lakes of San Luis valley," and that number 1069 follows next, this unusual *Rorippa* probably came from there. It should be sought along rivers and lakes of southwestern Colorado.

Summary of Section Sinuatae. Two evolutionary lines of morphological development are present in *Sinuatae.* One group—*R. calycina*, *R. columbiae*, and *R. subumbellata*—is characterized by slender, elongate-pointed trichomes, oblong to subglobose siliques rounded at the apex, persistent sepals, and seeds usually fewer than 35 per silique. The other group—*R. sinuata* and *R. ramosa*—is distinctive in having hemispherical vesicular trichomes, short- to elongate-cylindrical siliques pointed at the apex, caducous sepals, and seeds usually more than 35 per silique. Characters of the groups converge in *R. coloradensis.* The distributions of species of *Sinuatae* do not overlap, except for *R. sinuata* and *R. columbiae* along the Columbia River.

Sinuatae is probably a very old group of plants once more widespread and more variable but now differentiated and isolated, especially those with oblong to subglobose fruits. For comparison we can look to such species complexes as *R. curvisiliqua* and *R. palustris*, today probably undergoing an evolutionary explosion. These two complexes show tremendous variation in certain areas central in their ranges. Radiating from these centers are clinal variation and segregation of character combinations. These segregates often become confined to river valleys or mountain ranges. Morphological differences have been built up, but there appear to be interbreeding and gene flow among them, often where ranges overlap, so that character combinations distinguishing a particular segregate are sometimes in part obscured. This variation pattern justifies recognition of infraspecific taxa (varieties). These highly variable, polymorphic species complexes are today undergoing speciation, and if some catastrophe (shifting of land forms or a drying of the habitat), or various mechanisms to prevent interbreeding were to intervene, particularly in areas of overlap of the varieties, we would expect the surviving isolated populations to diverge morphologically and become well-defined species.

When the region was more mesic and had more wet habitats, one of these species complexes (the group with the oblong to subglobose fruits) in western North America had one line of development in the region of the Yellowstone River, one on the basaltic lava formation of the Columbia River, and one extending toward Lake Tahoe. The center of diversity may have been in present Colorado. Throughout time these plants were subjected to rigors of the environment and competition from other plants. Drying of the habitat probably was a major factor in bringing about isolation. The result was that intermediates, both morphological and geographical, died out. The population was isolated into several segments and the plants in each area may have kept their original prototype or continued to diverge morphologically. The remnants of this once widespread complex, *R. calycina*, *R. columbiae*, and *R. subumbellata*, are three of the most well-defined species in the genus.

Species of *Sinuatae* have characters considered primitive: perennial growth habit, clone formation, petals longer than the sepals, elongate anthers apiculate at the apex, long styles, and the relatively few and large, prominently colliculate seeds. These further support the idea that the group is an old one. Species in section *Rorippa*, which are annuals and possess derived or advanced characters, are believed young in comparison to those of *Sinuatae*, an idea discussed later.

SECTION RORIPPA

Section *Rorippa*

Spring, summer, fall, or winter annuals, rarely biennials or perennials; stems erect, decumbent, or prostrate, simple to much branched, one to many from a slender to thick vertical taproot, not spreading by underground roots or forming clones; basal rosettes present; basal and lower cauline leaves obovate, oblanceolate, lanceolate to spatulate in outline, unlobed to variously laciniate, pinnatifid, lyrate, or pectinate, rarely sinuate, thin, not fleshy; tips of young sepals and auricles (if present) of leaves usually sparingly hirsute; petals pale yellow, usually not showy, mostly shorter than the sepals or absent; anthers globose to subglobose, somewhat lobed at the base, ca. 1-1.5 times as long as wide, notched at the apex (fig. 8-A, 2); style usually shorter than 1 mm. in fruit.

Rorippa microtitis and *R. mexicana*, placed in this section for convenience, have petal and anther characters of *Sinuatae*. Showy petals longer than the sepals occur also in certain varieties of *R. curvipes*, *R. curvisiliqua*, and *R. palustris*, and elongate anthers reappear in *R. barbareifolia*. My characterization of section *Rorippa* is for the native North American taxa. Introduced species from Eurasia show some character combinations of both sections.

Fifteen species of North American *Rorippa* belong to section *Rorippa*.

7. RORIPPA TENERRIMA Greene, Erythea 3: 46. 1895. [as "*Roripa*"]; emended Pittonia 3: 96. 1896. (Holotype: CALIFORNIA: Modoc Co.: [Without locality], 1894, *Mrs. R. M. Austin s.n.*, ND-G 5513!)

Cardamine palustris ("Leysser" [Linnaeus]) O. Kuntze α *brevipes* (A. P. DeCandolle) O. Kuntze 3. *umbrosa* O. Kuntze, Rev. Gen. 1: 24. 1891. ("Engelm[ann] msc." Lectotype: MISSOURI: [St. Louis Co.]: Sandy woods on the Mississippi [River] above St. Louis, May 1845, *George Engelmann s.n.*, MO! Photo at MICH! OS! Isolectotype, GH! [The specimens were originally labeled "Nasturtium obtusum umbrosum" by Engelmann.])

Radicula tenerrima (Greene) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Glabrous summer, fall, and winter annual; stems 1-2 dm. long, decumbent to prostrate, much branched from the base; basal and cauline leaves short-petiolate, non-auriculate, non-clasping, oblong, oblanceolate to spatulate, 2-5(8) cm. long, 0.8-1.5 cm. wide, lyrate-divided nearly to the midrib, rarely undivided, the middle lobes oblong to elliptic, 3-6(10) mm. long, 1-4(9) mm. wide with entire margins, the terminal lobe wider than the laterals and obtuse at the apex; racemes terminal and axillary, ca. 0.5-1 dm. long, forming simultaneously during stem elongation, the siliques therefore nearly equal in age at corresponding points on the racemes, or racemes lateral, developing during stem elongation in the axils of the lower leaves and progressing upward, without the formation of a true terminal raceme, the oldest siliques therefore on the lower axillary racemes; pedicels (1)1.7-3(4.2) mm. long, ascending, glabrous to rough with minute papillae; sepals ovate to oblong, 0.7-1.2 mm. long, 0.4-0.6 mm. wide, flat, caducous in fruit; petals oblong to very narrowly spatulate, 0.6-0.8 mm. long, 0.1-0.3 mm. wide, 0.2-0.4 mm. shorter than the sepals; siliques elongate-cylindrical, slightly curved inward, occasionally curved outward, obtuse below and tapering toward the apex, (2)3.5-7(8.5) mm. long, 0.8-1.7(2.3) mm. wide, ca. 3-5(7) times as long as wide, ca. 1.5-2.5(4) times as long as the pedicels, the valves rough with minute papillae; replum oblong to narrowly elliptic in outline and the margin straight to concave; style (0.1)0.5-1 mm. long, ca. 0.2-0.4 mm. wide in fruit, tapering toward the apex, gradually merging into the pointed silique apex; stigma unexpanded in fruit; seeds regularly cordiform, ca. 0.5-0.7 mm. long, ca. 20-40 per silique, the surface reddish brown, finely colliculate; flowering and fruiting (May)June-October.

ILLUSTRATIONS: Britton & Brown (1897, p. 124, fig. 1715; 1913, p. 160, fig. 2028); same illustration in Abrams (1944, p. 281, fig. 2026), labeled either as *Rorippa* or *Radicula obtusa.* (The drawing is somewhat atypical in that the enlarged silique does not taper toward the apex, the style is somewhat abruptly attached, and the stigma is slightly expanded. The growth habit, ascending pedicels, and the leaves are more characteristic.)

Rorippa tenerrima is very distinct in being decumbent to prostrate, delicate, glabrous, freely branched, and usually up to 1-2 dm. long. Glabrous, lyrate-divided, entire leaves are best developed in this species. The elongate, slender, cylindrical siliques on very short, filiform, ascending pedicels taper toward the apex and are usually curved inward toward the raceme axis. The valves are minutely papillose. An unexpanded stigma tops the style, which gradually merges into the pointed silique apex. Morphologically *R. tenerrima* shows close relationship to *R. curvisiliqua*, especially var. *orientalis*.

Rorippa tenerrima first received formal recognition by Kuntze (1891) when he applied the name *Cardamine palustris* α *brevipes* 3. *umbrosa* to this taxon, citing "Engelm msc." as his source of information. A specimen (MO) labeled by Engelmann as "Nasturtium obtusum umbrosa" must have been the basis for Kuntze's name. Kuntze was in St. Louis in September 1874 and may have seen the Engelmann specimen then. I have selected the specimen at MO as the lectotype.

Greene's description (1895) agrees with my concept of this species, although the holotype is somewhat atypical in its nearly smooth valve surface and rather short (ca. 2-4 mm. long), apically acute fruits, these suggesting *R. curvipes* var. *curvipes*. Greene (1896) later pointed out that the ovaries [valve surface] were minutely scabrous. He also said he had detected, the previous summer in Nevada, a plant identical with the type collected by Mrs. Austin. One specimen collected on "27 July 1896, Cañon above Golconda [Nevada]" (ND-G 5515), was labeled by him *R. tenerrima* and may be the plant he had in mind when he emended his description. This delicate, glabrous plant with minutely papillose fruits and lyrate leaves matches my concept of the species.

Rorippa tenerrima has not been generally recognized as a separate species. Watson (1895) (or his editor, Robinson), not having seen specimens, quoted Greene's description. Howell's (1897) description was essentially Greene's rewritten slightly. Most western United States floras since 1900 have treated *R. tenerrima* within *R. obtusa*, except Harrington (1954), who accurately described it under *R. lyrata*. The plants at US, the basis for the report of *Radicula lyrata* by Standley (1921) from Glacier National Park, are *R. tenerrima*. Most specimens of *R. tenerrima* from the Pacific Northwest and from east of the Rocky Mountains have been called *R. obtusa*. In Utah, Nevada, and Colorado, the name *R. lyrata* often has been used, and in southern California, the name *R. curvisiliqua*.

DISTRIBUTION: Map 4; 20-F.

On the basis of morphological data and geographical position, *R. tenerrima* is the end of one evolutionary line in section *Rorippa* (map 20-F). Its sparse occurrence over a wide area of western United States is of great interest, suggesting a relic species, more abundant in the past, which has persisted in favorable habitats in isolated localities, particularly along major rivers such as the Columbia, Missouri, Rio Grande, Platte, and Humboldt. These rivers have doubtless aided in the dispersal of this species.

8. RORIPPA CURVISILIQUA (Hooker) Bessey ex Britton, Mem. Torrey Club 5: 169. 1894. [as "*Roripa*"]

Sisymbrium curvisiliquum Hooker, Fl. Boreal Am. 1: 61. 1830. ("Common on the North-West coast of America, lat. 47°48′, in sandy soils, near streams. *Douglas*." Holotype: WASHINGTON: [Probably Gray's Harbor or Jefferson Co. Specimen not seen, presumably at KEW.])

Cardamine indica (Linnaeus) O. Kuntze ε *normalis* ("sensu Hooker et Thompson" [O. Kuntze]) 2. *curvisiliqua* ("Nuttall" [Hooker]) O. Kuntze, Rev. Gen. 1: 24. 1891.

Radicula curvisiliqua (Hooker) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Nasturtium curvisiliqua (Hooker) Nuttall in Torrey et Gray, Fl. N. Am. 1: 73. 1838. (Nuttall's specimens actually belong to *Rorippa sinuata* (Nuttall in Torrey et Gray) A. S. Hitchcock, and are at BM, GH in part! NY! PH!.)

Summer, fall, or winter annual, occasionally biennial; stems 1-6 dm. long, erect, decumbent, or prostrate, single or much branched from the base, glabrous to moderately covered with very slender, short, retrorse, pointed trichomes; basal and cauline leaves sessile to short-petiolate, auriculate, clasping to non-auriculate and non-clasping, oblong, obovate, oblanceolate, spatulate, or rhombic-spatulate, (2)4-10(15) cm. long, 0.8-2(3.5) cm. wide, crenate to serrate, repand, incised, or pinnatifid to pectinate, both surfaces glabrous to hirsute, the middle lobes oblong, elliptic, or linear, 3-10(18) mm. long, 1-6(10) mm. wide with margins entire to minutely toothed, the apex obtuse to acute; racemes terminal and axillary, ca. (0.4)0.8-2 dm. long, forming simultaneously during stem elongation, the siliques therefore nearly equal in age at corresponding points on racemes; pedicels 1.1-5(7) mm. long, divergent to ascending, not recurved, glabrous to sparingly hirsute with very slender, short, retrorse, pointed trichomes; sepals ovate to oblong, 1.1-2.5 mm. long, 0.6-1.2 mm. wide, flat, caducous to persistent in young fruit; petals oblong, oblanceolate, to narrowly spatulate, 0.6-3(3.5) mm. long, 0.3-1.2 mm. wide, equal to the sepals or as much as ca. 0.5 mm. shorter or longer than them, spreading between the sepals; siliques elongate-cylindrical, straight to strongly falcate toward the raceme axis, obtuse below and not at all or slightly tapering toward the apex, (2.4)4-12(17) mm. long, 0.4-2 mm. wide, ca. (4)5-12(17) times as long as wide, ca. 2-5(8) times as long as the pedicels, the valves thin and readily dehiscent or turgid and sparingly or not at all dehiscent, smooth, glabrous; replum narrowly oblong in outline, the margin straight and glabrous or finely hirsute; style 0.1-0.8 mm. long, ca. 0.2-0.5 mm. wide in fruit, tapering toward the apex or slightly expanded below the stigma, gradually merging into the acute silique apex; stigma unexpanded and occasionally 2-lobed in fruit; seeds regularly to angularly cordiform to somewhat oblong, ca. 0.5-0.7 mm. long, ca. 30-60 per silique, the surface reddish to yellowish brown, colliculate to recticulate-foveolate; flowering and fruiting March-October.

Rorippa curvisiliqua, a variable species with intergrading geographical segregates, is distinct from all other *Rorippa* in North America. The replum margin is either glabrous or minutely hirsute. When glabrous, the valves are very turgid and are not readily dehiscent, the seeds sometimes remaining in the pod all winter. When hirsute, the valves are readily dehiscent and not turgid. The pedicels and stems are usually covered with very slender, pointed, short, retrorse trichomes, but occasionally plants are glabrous, as best shown in var. *nuttallii.* In living plants, the petals spread outward between the sepals, resulting in more showy flowers, particularly in the Pacific Northwest, where the petals are longer than the sepals. In certain varieties the sepals tend to persist after the petals have fallen or even during silique maturation. In this character, *R. curvisiliqua* is similar to the short- and oblong-fruited members of *Sinuatae*. From fully mature fruits, however, the sepals have usually fallen.

Rorippa curvisiliqua shows morphological and geographical relationship to *R. sinuata*, *R. tenerrima*, *R. microtitis*, and *R. curvipes*. Its distribution, for the most part, lies adjacent to the first three of these. *Rorippa sinuata* is distributed to the east of *R. curvisiliqua*, but their range overlaps along the Snake and Columbia rivers. The two differ in petal length, trichomes, growth habit, pedicel and style length, and sepal longevity. They are similar in slender strongly falcate siliques, and a style gradually merging into the silique apex. Cauline leaves of var. *curvisiliqua* from Montana and Wyoming are very similar, but they are more deeply pinnatifid and pectinate in plants from Idaho, Washington, and Oregon.

Rorippa curvisiliqua is allied via var. *orientalis* to *R. tenerrima*, which it closely resembles in growth habit, silique size and shape, pedicel length, attachment of the style, and sometimes in the leaves. Variety *orientalis* differs from *R. tenerrima* in having the replum margin minutely hirsute, slender retrorse trichomes on pedicels and stem, glabrous valves, a tendency for the stigma to be 2-parted in fruit, and leaves usually pinnatifid to the midrib with the entire to irregularly toothed lobes more elliptic and pointed rather than oblong and blunt. Relationship between the two is suggested by a specimen from eastern California (*Mahurin 123*, ND), which has rough valves of *R. tenerrima* but leaves and trichomes of *R. curvisiliqua* var. *orientalis*. The western Nevada specimens of the latter variety having lyrate leaves are indeed very similar to *R. tenerrima* in this character. When Greene (1896) emended his description of *R. tenerrima*, he also included some lyrate-leaved plants that grew "along the Lower Humboldt and Truckee rivers in western Nevada and eastern California." These are *R. curvisiliqua* var. *orientalis*.

The relationships of *R. curvisiliqua* to *R. microtitis* and to *R. curvipes* var. *integra* are discussed under those taxa.

Most United States manuals have correctly interpreted *R. curvisiliqua* as a species. However, much variation is seen in treatment of the varieties, and often their recognition has been avoided. Plants called *R. curvisiliqua* in the *Arizona Flora* (Kearney and Peebles, 1951) are *R. microtitis* (see my discussion under that species), as are those reported by Shreve and Wiggins (1964). *Rorippa curvisiliqua* apparently does not grow in Arizona or Lower California.

Rorippa curvisiliqua represents perhaps the most difficult species complex because of its great morphological variation in its relatively limited range. The species is limited to west of the Continental Divide (except in Montana). Its morphological segregates correlate with some physiographic features such as river valleys and mountain ranges. There are strong phenological differences between certain segregates. Two varieties may grow together but flower and fruit at different times. Thus, geographical and phenological isolation has helped keep the varieties separate and distinct in some areas. In others, geographical distribution and phenology overlap; here there may or may not be morphological intermediates. Each variety may intergrade into one or more others, but each is quite distinct where it is isolated from certain others. The plants are most variable in northern Idaho and eastern Washington. Here nearly all varieties and plants transitional between them are found. Outward from this center clinal variation occurs, particularly along the Columbia River.

DISTRIBUTION: Map 5; 6; 7; 20-G.

Moisture apparently influences the eastern and southeastern limits of *R. curvisiliqua*, this species being absent from the dry regions of eastern Montana, central Wyoming, Nevada, and parts of southern California. The species is most frequently found in areas of continental northwestern United States that receive over 16 inches of annual rainfall (see map 7, to which I have added the 16-inch isohyet).

Descriptive Key to Varieties of Rorippa curvisiliqua

1. Plants erect; pedicels longer than 3 mm. (except in var. curvisiliqua from Idaho and westward and in var. occidentalis); siliques (5)8-17 mm. long (except in var. curvisiliqua and var. spatulata); petals usually equal to or longer than the sepals (except in var. occidentalis) (2)

1. Plants prostrate; pedicels shorter than 3 mm.; siliques (2.4)4-8.3(12)

mm. long; petals usually shorter than the sepals (6)

2. Pedicels shorter than 3 mm.; petals 0.8-1.5 mm. long; cauline leaves mostly more than 10 (except in var. occidentalis) (3)

2. Pedicels longer than 3 mm.; petals 1.5-3 mm. long; cauline leaves mostly fewer than 10 (4)

3. Siliques strongly falcate, (2.4)4-8.3(10) mm. long, 0.4-1.1 mm. wide; valves readily dehiscent, not turgid; replum margin minutely hirsute; basal leaves broadly oblanceolate, pectinate or somewhat pinnatifid; lobes linear, the middle ones mostly narrower than 2 mm.; cauline leaves oblanceolate, pectinate to deeply pinnatifid or unlobed, sinuate or sharp to blunt dentate-margined; cauline leaves mostly more than 10; sepals persistent in young fruit. . . . . 8a. var. *curvisiliqua*

3. Siliques straight, (5)8-17 mm. long, (0.8)1.1-2 mm. wide; valves strongly turgid and not readily dehiscent; replum margin glabrous; basal and cauline leaves rhombic-spatulate to oblanceolate, unlobed to variously irregularly lobed, entire, repand or blunt dentate-margined; cauline leaves mostly fewer than 10; sepals caducous in young fruit. . . . . 8g. var. *occidentalis*

4. Stems, pedicels, and replum margin glabrous or very sparingly hirsute; valves strongly turgid and not readily dehiscent; petals mostly (2)2.5-3 mm. long; siliques (5)8-17 mm. long, 1.1-2 mm. wide; basal and cauline leaves broadly oblanceolate, pectinate; lobes linear, the middle segments mostly narrower than 2 mm.; sepals caducous in young fruit; flowering and fruiting March-May and October. . . . . 8b. var. *nuttallii*

4. Stems, pedicels, and replum margin sparingly to rather densely hirsute; valves readily dehiscent and not strongly turgid; petals 1.5-2.5 mm. long; siliques, leaves, and sepals as in couplet 5; flowering and fruiting from June to September (5)

5. Siliques (5)8-17 mm. long, 1.1-2 mm. wide; basal and cauline leaves oblong to slightly oblanceolate, pinnatifid, lobes oblong, the middle segments mostly wider than 3 mm., their margins serrate or toothed; sepals sparingly persistent in young fruit; northern Idaho, eastern Washington, and along the Columbia River. . . . . 8e. var. *lyrata*

5. Siliques 4-8(12) mm. long, 0.4-1.2 mm. wide; basal and cauline leaves oblanceolate to rhombic-spatulate, not pinnatifid, the margins repand to entire; sepals strongly persistent in young fruit; central Oregon, central Idaho, and northwestern Wyoming. . . . . 8f. var. *spatulata*

6. Leaves broadly oblanceolate, pinnatifid to the midrib or occasionally lyrate, the lobes mostly elliptic to oblong, their margins entire or slightly dentate; petals 0.6-1.5 mm. long; stigma usually 2-lobed in fruit; siliques straight, 0.7-1.5 mm. wide; valves readily dehiscent and not turgid; replum margin minutely hirsute; stem usually straight; plants up to ca. 2.5 dm. long. . . . . 8c. var. *orientalis*

6. Leaves oblanceolate, unlobed, the margins sharply dentate; petals 1-2.5 mm. long; stigma unlobed in fruit; siliques falcate, 0.4-1 mm.

wide; valves turgid, not readily dehiscent; replum margin glabrous; stem usually crooked; plants usually over 3 dm. long. . . . .
. . . . 8d. var. *procumbens*

8a. RORIPPA CURVISILIQUA (Hooker) Bessey ex Britton var. CURVISILIQUA

ILLUSTRATIONS: Abrams (1944, p. 281, fig. 2025); Britton & Brown (1897, p. 126, fig. 1719).

Two geographical variations occur in var. *curvisiliqua*. In northern Idaho, northern Washington, and coastal Washington, Oregon, and northern California, the plants are tall, mostly over 4 dm. (the tallest in the species), both basal and lower cauline leaves are pectinate, and the pedicels are very short (mostly less than 3 mm.). In northern Idaho and along the Columbia River the plants flower and fruit in April, May, early June, and October, whereas the plants from other areas flower not only in early spring and late fall but also in summer. The second variation occurs in western Montana and northwestern Wyoming. These plants tend to be shorter (up to ca. 3 dm.), have cauline leaves mostly sinuate or sharp to blunt dentate-margined, and pedicels usually longer than 3 mm. Flowering and fruiting occur in summer. From the center of diversity in northern Idaho, var. *curvisiliqua* reaches southeastward in the Rocky Mountains as far as the Grand Tetons in Wyoming, and westward across Washington and down the coast to San Francisco Bay. The two variations do not seem distinct enough to merit varietal recognition.

Synonymy for var. *curvisiliqua* is presented before the species description. Hooker's description, quite complete, characterizes this variety well. He described the plants as barely a foot high, the lower leaves subpectinate pinnatifid, and the silique scythe-shaped—features distinctive for the typical variety. Furthermore, he gave the source locality as "North-West coast of America, lat. 47°48′." On the coast at this latitude, only var. *curvisiliqua* has been collected. Variety *procumbens*, which might be expected in coastal Washington, has unlobed, strongly dentate leaves. Hooker's description of the leaves does not characterize var. *procumbens*.

Abrams' (1944) illustration of *R. curvisiliqua* is very representative of var. *curvisiliqua*. However, the illustration for var. *curvisiliqua* in Hitchcock and Cronquist (1964), a plant with unlobed, dentate leaves, is var. *procumbens*.

DISTRIBUTION: Map 5.

8b. RORIPPA CURVISILIQUA (Hooker) Bessey ex Britton var. **nuttallii** (S. Watson) Stuckey, comb. nov.

Nasturtium polymorphum Nuttall in Torrey et Gray, Fl. N. Am. 1: 74. 1838. ("Banks of the Oregon [River]." Holotype: OREGON or WASHINGTON: [county unknown]: Columbia R[iver], [ca. 1834, *fide* Pennell (1936, p. 36), *Thomas Nuttall s.n.*], BM. Photo no. BM 2128, GH! Isotypes, GH! PH! Photo of PH specimen at MICH! OS! [The specimens were originally labeled "Nasturtium *polymorphum" by Nuttall.])

Nasturtium curvisiliqua (Hooker) Nuttall in Torrey et Gray, var. *nuttallii* S. Watson in Gray, Syn. Fl. N. Am. 1: 148. 1895. [Based on an isotype of *Nasturtium polymorphum* Nuttall in Torrey et Gray. Specimen at GH!]

Roripa [sic] *polymorpha* (Nuttall in Torrey et Gray) Howell, Fl. N. W. Am. 1: 41. 1897.

Roripa [sic] *nuttallii* (S. Watson) Rydberg, Mem. N. Y. Bot. Gard. 1: 176. 1900.

Radicula polymorpha (Nuttall in Torrey et Gray) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Radicula nuttallii (Rydberg) Greene, Leafl. Bot. Obs. & Crit. 1: 114. 1905.

Roripa [sic] *pectinata* A. Nelson, Proc. Biol. Soc. Wash. 20: 35. 1907. (" . . . at The Dalles, Oregon, by Dr. J. Lunell, April 12 and April 16, 1903. The latter is the type and is deposited under the accesson No. 54984. Secured again by the same collector, in mature condition, May 4, 1906, at the type station." Holotype: OREGON: [Wasco Co.]: The Dalles, 16 Apr 1903, *J. Lunell s.n.* [Specimen not seen, presumably at RM 54984.] Paratypes: OREGON: [Wasco Co.]: The Dalles, 12 Apr 1903, *J. Lunell s.n.*, US! In alluvial soil along the Columbia River at the type station, The Dalles, 4 May 1906, *J. Lunell s.n.*, GH! MO! NY! PH! US! WIS!)

Radicula pectinata (A. Nelson) Heller, Muhlenbergia 7: 124. 1912.

Radicula curvisiliqua (Hooker) "Bessey" [Greene] var. *hallii* attributed to Watson by Peck, Man. High. Pl. Oreg. 344. 1941. [Erroneously reported as "*Roripa* [sic] *curvisiliqua* var. *hallii*" by Hitchcock and Cronquist, Univ. Wash. Publ. Biol. 17: 535. 1941]

Radicula curvisiliqua (Hooker) "Bessey" [Greene] var. *nuttallii* attributed to Watson by Peck, Man. High. Pl. Oreg. 344. 1941.

The tendency to retain the turgid valves after seed formation is best developed in var. *nuttallii*. My collections from the Columbia River at The Dalles (*1910A*) and Hood River (*1912A*), Oregon, are of plants whose fruits had matured much earlier as the leaves died off, but the siliques still retain valves and seeds. A specimen of var. *nuttallii* (*Cronquist 5685*, NY) collected on 7 April 1949 at Maryhill, Washington, has a portion of the previous year's gray-black stem from which sprouted the present green stems and leaves. On this old stem are several old gray-black, still-intact siliques, clearly indicating the valves may persist a long time and even withstand the winter.

Watson (1895) first accorded this entity varietal rank under the name *nuttallii* based on one of the original collections of Nuttall's *Nasturtium polymorphum*. Nelson's (1907) description of *R. pectinata* is an excellent recharacterization of Nuttall's plant based on Lunell's collections made at The Dalles, Oregon. Peck (1941) attributed a var. *hallii* to Watson, but this name was never published. In fact it seems that Watson never proposed such a variety. On the original label of a collection by Howell (*1406* GH), Watson wrote "var. *nuttallii*," but the "n" and "u" are somewhat obscured by the "y" of the crossed-out word "polymorphum" written above. The two "t's" are not perfectly crossed, thus creating a rather large "H," resulting in the word "Hallii." Anyone not looking carefully at the label could easily make this mistake (as did I at first), and it appears that this is what Peck did (assuming that Peck saw this or a duplicate label written in the same manner). Peck, using the generic name *Radicula*, was apparently unaware that he was making new combinations of *Radicula curvisiliqua* in varietal rank.

In Idaho and the upper Columbia River valley are plants intermediate between var. *curvisiliqua* and var. *nuttallii* in height, number of cauline leaves, silique shape and width, and pedicel and petal length. Downstream along the Columbia the plants begin to approach those of var. *nuttallii*, so that by the time the Oregon-Washington border is reached, var. *curvisiliqua* is replaced by var. *nuttallii*, known only from the banks of the Columbia from The Dalles to Sauvies Island. At Sauvies Island, var. *nuttallii* again contacts var. *curvisiliqua*, and intermediates between the varieties, like those of the upper Columbia River valley, are found. The intermediates are shown by "triangles" in map 5. Out of the variable complex in Idaho and the upper Columbia River valley has been morphological divergence in two directions—across northern Washington and along the Pacific coast (var. *curvisiliqua*), and down the Columbia River (var. *nuttallii*), the two then apparently hybridizing where they meet in the lower Columbia River at Bingen (not mapped) and on Sauvies Island. Both varieties flower in early spring and late fall in these localities. In *Rorippa*, var. *nuttallii* is the best example of plants apparently migrating downriver, becoming isolated, and changing morphologically in the process.

DISTRIBUTION: Map 5.

8c. RORIPPA CURVISILIQUA (Hooker) Bessey ex Britton var. **orientalis** Stuckey, var. nov. (Holotype: CALIFORNIA: Eldorado Co.: Local in sandy soil under pine trees where boat trailers were parked on beach of Lake Tahoe at Meeks Bay, ca. 6100 ft [ca. 1830 m], 28 Jul 1963, *R. L. Stuckey 1939*, MICH! Photo at MICH! Isotypes to be distributed. Fig. 2.)

Herba annua procumbens; foliis late oblanceolatis, pinnatilobatis vel lyratis; lobis ellipticis vel oblongis integris vel dentatis; petalis 0.6-1.5 mm. longis; stigmatibus vulgo bilobatis; siliquis rectis (2.4)4-8.3(12) mm. longis, 0.7-1.5 mm. latis; pedicellis diversis.

ILLUSTRATIONS: Fig. 2; Jepson (1925, p. 425, fig. 415)

Variety *orientalis* is a summer-flowering plant similar to var. *curvisiliqua* and var. *nuttallii* in having deeply divided leaves with narrow segments. It represents a miniature var. *curvisiliqua* in height and petal length, and a miniature var. *nuttallii* in silique and pedicel length. Where flowering time of var. *orientalis* overlaps that of var. *curvisiliqua* in central Idaho, intermediates between the varieties are found. These are shown as "stars" in

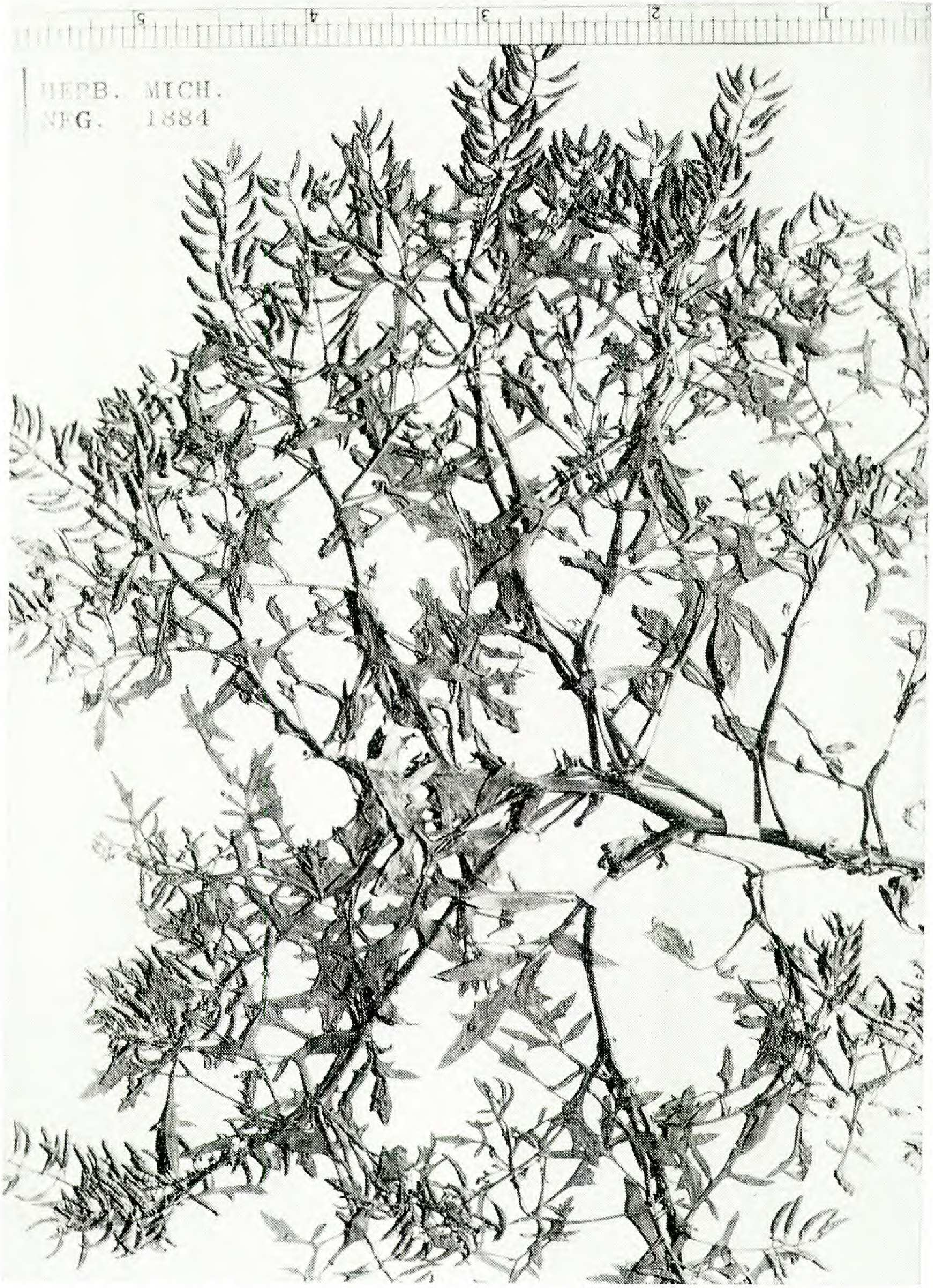


Fig. 2. Photograph of a portion of the holotype of *Rorippa curvisiliqua* (Hooker) Bessey ex Britton var. *orientalis* Stuckey. (*R.L. Stuckey 1939*, MICH). Univ. Mich. Neg. No. 1884.

map 5. Variety *orientalis* is best developed morphologically in wet places in mountains of eastern California. In this region it is distinct from its closest relative, var. *curvisiliqua.*

DISTRIBUTION: Map 5.

8d. RORIPPA CURVISILIQUA (Hooker) Bessey ex Britton var. **procumbens** Stuckey, var. nov. (Holotype: CANADA: BRITISH COLUMBIA: Stony Creek, Pemberton Trail, 24 Jun 1916, *J. M. Macoun 91904*, NY! Photo at MICH! Isotype, GH! Fig. 3.)

Herba annua procumbens; foliis oblanceolatis integris vel dentatis; petalis 1-2.5 mm. longis; stigmatibus inlobatis; siliquis falcatis (2.4)4-8.3(12) mm. longis, 0.4-1 mm. latis; pedicellis diversis.

ILLUSTRATIONS: Fig. 3; Hitchcock & Cronquist (1964, p. 538), as var. *curvisiliqua.*

Variety *procumbens* is very similar to var. *curvisiliqua*, and the two have not been distinguished in the herbarium or the literature. Although both have very short pedicels and short, slender, strongly falcate siliques, they differ in growth habit, leaf morphology, and in certain features of the fruits (compare data in the key). One can readily determine from herbarium specimens that these plants grow prostrate—the stem is often bent at the base and often crooked throughout, and the leaves frequently appear one-sided on the stem. This variety is best developed morphologically in Canada and Alaska, growing by itself without the immediate influence of other varieties. In northern Idaho, the plants flower and fruit during summer; in this manner, var. *procumbens* is isolated from var. *curvisiliqua*, which flowers in early spring and late fall. In Washington and Oregon, the plants appear more often to flower and fruit during spring at the same time as var. *curvisiliqua.* The factors keeping the varieties relatively distinct in this region need investigation. The few California specimens suggest early spring flowering from March to May that tends to isolate this variety from var. *occidentalis*, which flowers primarily from May into summer.

Variety *procumbens* is in the center of diversity in northern Idaho. It extends across northern Washington northward to southeasternmost Alaska, and southward through western Oregon to the Central Valley of California.

DISTRIBUTION: Map 6.

8e. RORIPPA CURVISILIQUA (Hooker) Bessey ex Britton var. **lyrata** (Nuttall in Torrey et Gray) Stuckey, comb. nov.

Nasturtium lyratum Nuttall in Torrey et Gray, Fl. N. Am. 1: 73. 1838. ("Banks of the Oregon [River]." Holotype: OREGON or WASHINGTON: [county unknown]: Columbia shores, [ca. 1834, *fide* Pennell (1936, p. 36), *Thomas Nuttall s.n.*], BM. Photo no. BM 2127, GH! Isotype, PH! Photo at MICH! OS! [The specimens were originally labeled "Nasturtium *lyratum" by Nuttall.])

Nasturtium curvisiliqua (Hooker) Nuttall in Torrey et Gray var. *lyrata* (Nuttall in Torrey et Gray) S. Watson, Geol. Surv. Calif. Bot. 1: 43.

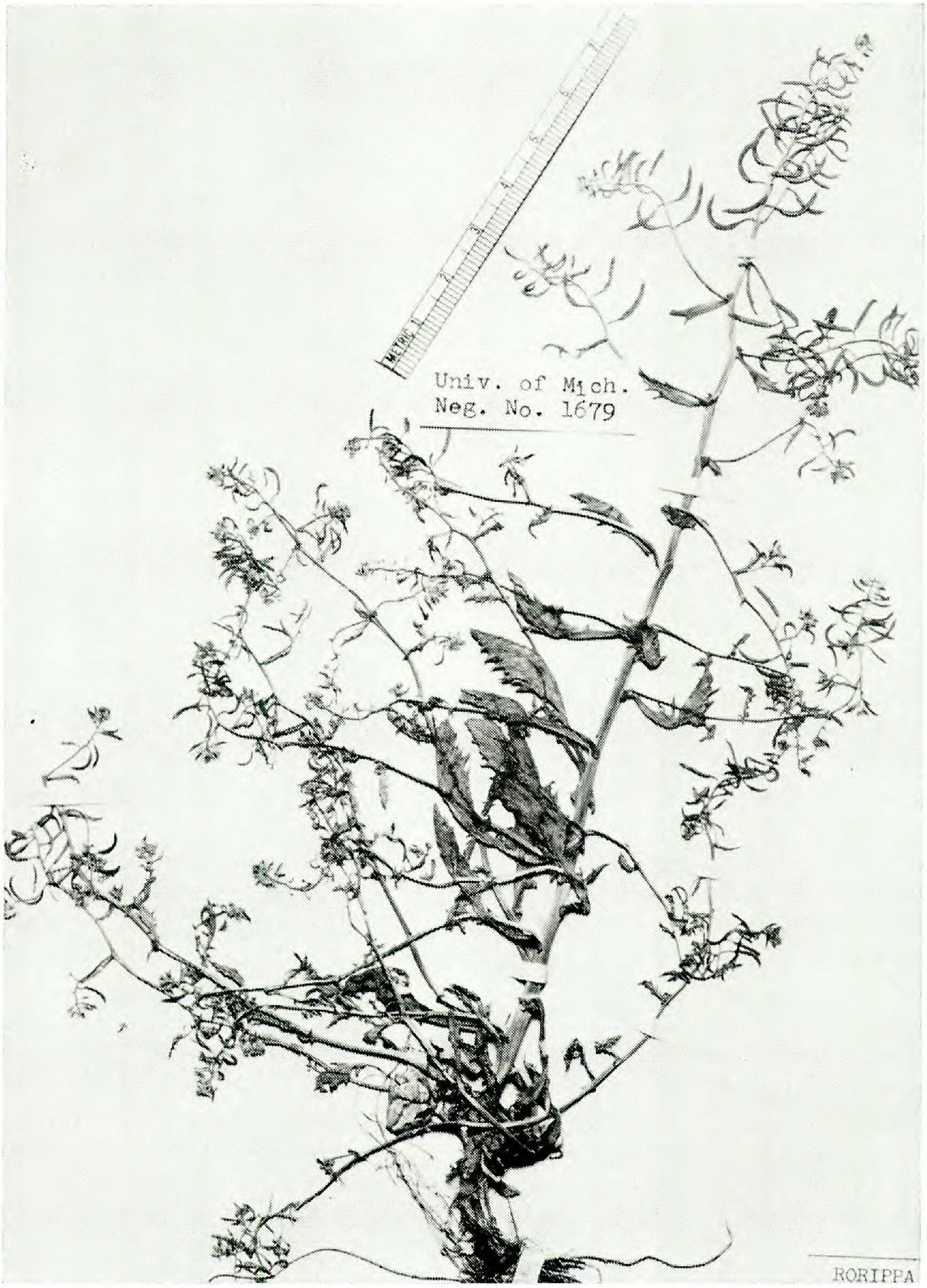


Fig. 3. Photograph of the holotype of *Rorippa curvisiliqua* (Hooker) Bessey ex Britton var. *procumbens* Stuckey. (*J.M. Macoun 91904*, NY). Univ. Mich. Neg. No. 1679.

1876.

Roripa [sic] *lyrata* (Nuttall in Torrey et Gray) Greene, Man. Bot. San Francisco Bay 20. 1894.

Radicula lyrata (Nuttall in Torrey et Gray) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Radicula curvisiliqua (Hooker) "Bessey" [Greene] var. *lyrata* (Nuttall in Torrey et Gray) attributed to Watson by Peck, Man. High. Pl. Oreg. 344. 1941.

Although occasionally a leaf is somewhat lyrate, a truly lyrate leaf, as in *R. tenerrima*, is not developed in var. *lyrata*. The leaves are oblong to slightly oblanceolate and pinnatifid with lobes serrate to dentate, much like those in Nuttall's type. Reports of *R. lyrata* by Harrington (1954) and Rydberg (1906) from Colorado, and by Standley (1921) from Montana, should be referred to *R. tenerrima*. The illustration in Hitchcock and Cronquist (1964) of var. *lyrata* is an excellent one—of var. *spatulata*.

Although var. *lyrata* is absent along the upper Columbia River in northeastern Washington, it does occur north into Canada and northern Idaho and probably has migrated west down the Snake River to the lower Columbia, where it is found in Washington and Oregon. Variety *lyrata* and var. *procumbens* intergrade in northern Idaho and eastern Washington. In that area, plants have leaves, pedicels, and silique length of var. *lyrata* but they are prostrate, have more than 10 cauline leaves per stem, and produce slender curved siliques—characters of var. *procumbens*. These intermediate plants are shown by "stars" in map 6.

Variety *lyrata* is very similar to var. *nuttallii* in size and growth form but differs as shown in the key. There is some intergradation in distinguishing characters, especially leaf morphology. The range of var. *nuttallii*, on the shores of the Columbia River, completely coincides with part of the range of var. *lyrata*, but a striking difference in flowering and fruiting time separates the two. All collections of var. *nuttallii* were made in March (plants in flower) or April or early May (plants in fruit) or in October; those of var. *lyrata*, only in summer from June to September.

I grew plants of var. *lyrata* from seeds of my collection *1927* and of var. *nuttallii* from collection *1912A*. The difference in leaf shape in the greenhouse plants was not as pronounced as in most herbarium material. Leaf lobes of living var. *nuttallii* were quite wide although entire or only slightly toothed. I do not know the leaf shape of the plants obtained in the field, since the leaves had withered and fallen. Fruit characters in the greenhouse plants were maintained. No change in leaf shape of the varieties came about when the plants were grown simultaneously under short or long days.

DISTRIBUTION: Map 6.

8f. RORIPPA CURVISILIQUA (Hooker) Bessey ex Britton var. **spatulata** Stuckey, var. nov. (Holotype: IDAHO: Blaine Co.: In dried up alpine pool, at head of Boulder, Sawtooth Nat[ional] Forest, Sawtooth Mts., 9000 ft, 6 Aug 1937, *J. William Thompson 14139*, MICH! Photo at

MICH!, Fig. 4. Isotypes, GH! US!)

ILLUSTRATIONS: Fig. 4; Hitchcock & Cronquist (1964, p. 538), as var. *lyrata*.

Herba annua erecta; siliquis 4-8(12) mm. longis, 0.4-1.2 mm. latis; foliis radicalibus caulinisque oblanceolatis vel rhombo-spathulatis fere integris; petalis 1.5-2.5 mm. longis; sepalis firme retentis.

The above-cited drawing, an excellent representation of this variety, closely matches the holotype. Variety *spatulata* is related to var. *lyrata* in petal length, readily dehiscent valves, trichomes on replum margin, and few cauline leaves per stem. Pedicels are quite variable in length, but the lowermost ones are usually over 3 mm. The specimen from Idaho County, Idaho (*Kirkwood 2015*, GH) has somewhat longer and wider siliques and approaches var. *lyrata* of that area. Like var. *lyrata*, var. *spatulata* also flowers and fruits in summer. Variety *spatulata* is also related to var. *occidentalis* in its rhombic-spatulate leaves.

Variety *spatulata* is known from northeastern and central Idaho westward to central Oregon.

DISTRIBUTION: Map 6.

8g. RORIPPA CURVISILIQUA (Hooker) Bessey ex Britton var. **occidentalis** (Greene) Stuckey, comb. nov.

Nasturtium occidentale Greene, Fl. Franciscana 2: 268. 1891. ("Very common on moist low plains bordering the upper Sacramento [River], and in the foothills adjacent." Lectotype: CALIFORNIA: [Butte Co.]: Near Chico, Jun 1890, *E. L. Greene s.n.*, ND-G 5150! Isolectotypes, ND-G 5148! ND-G 5152!)

Roripa [sic] *multicaulis* Greene, Pittonia 3: 97. 1896. ("Common on moist banks of the San Joaquin River, thence southward perhaps to Lower California." Lectotype: CALIFORNIA: San Joaquin Co.: Tracy, Apr 1892, *Michener & Bioletti s.n.*, ND-G 5141! Isolectotypes, ND-G 5144! US! Photo of the US specimen at MICH! OS!)

Roripa [sic] *occidentalis* (Greene) Greene, Pittonia 3: 97. 1896.

Radicula occidentalis (Greene) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Radicula multicaulis (Greene) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Characteristic of many specimens of var. *occidentalis* are the numerous siliques at the raceme apex. The siliques are quite sturdy, the valves turgid. Thus, when the plants are pressed, many siliques are turned and flattened perpendicular to the replum. Greene (1891) commented on this feature in his original description. This character recurs sparingly in var. *lyrata* from eastern Washington (*Horner R264B56*, GH; *Henderson 2383*, GH) and serves to link var. *occidentalis* with the center of diversity in the species. In leaves, var. *occidentalis* is similar to var. *spatulata*. In the Central Valley of California, where var. *occidentalis* is isolated from its northern relatives, it is

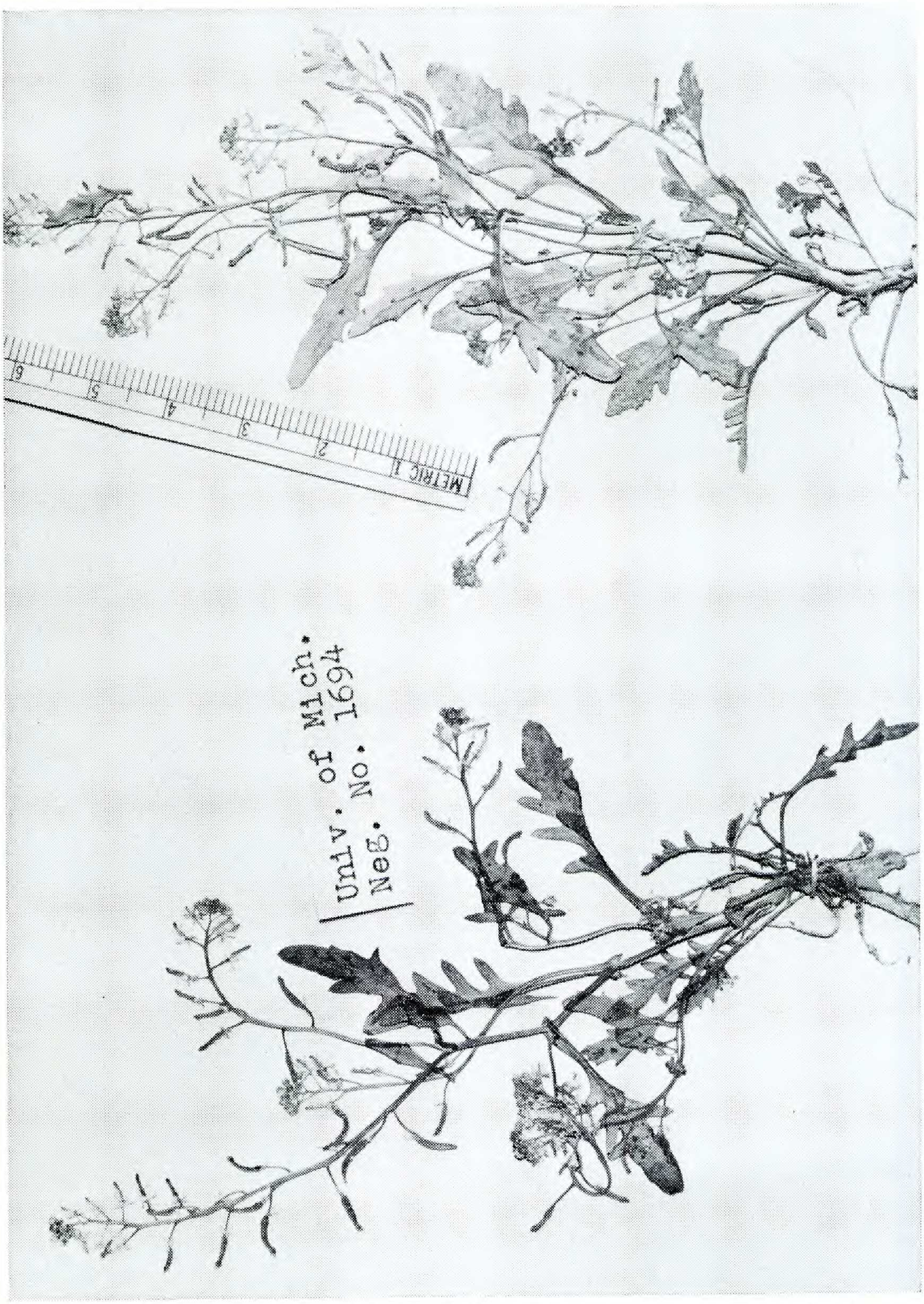


Fig. 4. Photograph of the holotype of *Rorippa curvisiliqua* (Hooker) Bessey ex Britton var. *spatulata* Stuckey. (*J.W. Thompson 14139*, MICH). Univ. Mich. Neg. No. 1694.

best developed morphologically.

Collections on which Greene (1896) based his *R. multicaulis* and several others he identified as that species are somewhat atypical of the usual material in central California. Plants from Tracy, California (*Michener & Bioletti s.n.*, ND-G 5141) have somewhat pectinate leaves, whereas other plants from there (*Michener & Bioletti s.n.*, ND-G 5144, US) have unlobed leaves very similar to the type of var. *occidentalis*. The plants are glabrous and the siliques are long (ca. 6-12 mm.) like those of var. *occidentalis*. The petals have fallen from the specimens in Greene's herbarium, but in the US specimen they are present and are less than 1 mm. long, the stigma in fruit is 2-parted, and the siliques are slender (ca. 1 mm. wide). In these characters Greene's *R. multicaulis* suggests var. *orientalis*; it is intermediate between the varieties. It is plausible that in the southern portion of the range of var. *occidentalis* where var. *orientalis* may have moved westward down the Sierra Nevada Mountains, the varieties may have introgressed. However, Greene's material comes from the eastern portion of the valley, somewhat removed from the closest localities of var. *orientalis*. More collections are needed to determine the variation pattern and possible reasons for its occurrence. For the present, *R. multicaulis* is placed in synonymy with var. *occidentalis*.

DISTRIBUTION: Map 6.

Summary of Rorippa curvisiliqua. Two somewhat morphologically defined groups occur in *R. curvisiliqua*: (1) plants with pectinate-pinnatifid leaves with narrow lobes (var. *curvisiliqua*, var. *nuttallii*, var. *orientalis*, map 5), and (2) plants with pinnatifid-spatulate leaves unlobed or with wide lobes (var. *lyrata*, var. *procumbens*, var. *spatulata*, var. *occidentalis*, map 6). These groups are nearly comparable to the subspecies designated in *R. palustris*, but morphological divergence in them is not so pronounced as in *R. palustris*. A well-defined character useful to separate the groups has not been found. Morphologically, only the variable leaves set them apart. The groups can also be somewhat defined phenologically. The pectinate-pinnatifid ones are primarily spring and fall flowering where they grow with members of the other group, but where they occur alone—in mountains of western Montana and eastern California—they are summer flowering. The pinnatifid-spatulate group is primarily summer flowering. Where all varieties (except two) grow together in northern Idaho and eastern Washington, plants flowering in early spring or late fall are of the pectinate group, whereas plants flowering in summer are of the spatulate group. Apparently where individuals of both groups grow together and overlap in flowering, hybridization and reshuffling of character combinations occur, forming intermediates.

In the key any one character occurs one, two, or more times in each variety of each group; these same characters have recombined variously to form the different entities. Thus the prostrate growth form has arisen in var. *procumbens* of the pinnatifid-spatulate group and in var. *orientalis* of the pectinate-pinnatifid group. Similarly, other features have arisen in one or more varieties of each group. This grouping of the same characters into various combinations to form the different segregates makes key writing extremely difficult.

The character combinations have arisen and have been selected for in various plants. Today we see the various segregates associated with certain physiographic areas. Where isolated from other varieties, they have become rather distinct morphologically. We find var. *curvisiliqua* growing alone in western Montana, var. *nuttallii* and var. *lyrata* along the Columbia River (but isolated phenologically), var. *spatulata* in the central basin of Idaho and Oregon, var. *procumbens* along the west coast from Alaska to central California, var. *orientalis* by itself in the Sierra Nevada of eastern California, and var. *occidentalis* in the central valley of California. The range of *R. curvisiliqua* is largely within a region that receives over 16 inches of rainfall per year (map 7).

9. RORIPPA MICROTITIS (Robinson) Rollins, Rhodora 59: 71. 1957.

Sisymbrium microtites Robinson, Bot. Gaz. 30: 59. 1900. (Holotype: MEXICO: CHIHUAHUA: Sierra Madre, 5 miles southeast of Colonia Garcia, 23 Jun 1897, *C. H. Townsend, C. M. Barber 43*, GH! Isotypes, NY! US!)

Nasturtium microtites (Robinson) O. E. Schulz, Repert. Sp. Nov. 34: 134. 1933.

Glabrous winter annual, possibly a short-lived perennial, from a taproot; stems 3-5 dm. tall, erect, one to few from the base; basal and cauline leaves petiolate, auriculate, but not clasping the stem, broadly oblanceolate, 5-12 cm. long, 1-3 cm. wide, pinnate-divided to pectinate, the middle lobes oblong, elliptic, or linear, (4)7-20 mm. long, 1-3(6) mm. wide, their margins entire to minutely toothed, the terminal lobe narrow, rounded at the apex; racemes terminal and axillary, ca. 1-2 dm. long, forming during stem elongation, the siliques therefore nearly equal in age at corresponding points on the racemes; pedicels divergent to ascending, 3.5-10.5 mm. long; sepals ovate to oblong, 2-2.8 mm. long, 0.6-0.9 mm. wide, saccate, caducous in fruit; petals spatulate, 2.5-3.7 mm. long, 0.6-1 mm. wide, 1-2 mm. longer than the sepals; siliques elongate-cylindrical, straight to slightly curved inward toward the raceme axis, obtuse below and not at all or only slightly tapering toward the apex, (8.5)10-16(20.1) mm. long, 0.8-1.9 mm. wide, ca. 7-11(13) times as long as wide, ca. 1.5-4 times as long as the pedicels, the valves apparently turgid and non-dehiscent (old, mature siliques not known); replum narrowly oblong in outline, the margin straight; style 0.5-1(1.3) mm. long, ca. 0.3-0.5 mm. wide in fruit, strongly tapering to the apex, gradually merging into the acute silique apex; stigma unexpanded in fruit; seeds (mature seeds not known, two immature ones examined) cordiform, ca. 0.6-0.7 mm. long, the surface reddish brown, reticulate-foveolate; flowering and fruiting June-August and probably on into the fall.

Rorippa microtitis is distinguished by a set of character combinations from both sections of the genus. It has the elongate apiculate anthers and long sulfur-yellow petals of section *Sinuatae*. In this respect it is closely related to *R. sinuata*. The plants do not form new plants from the roots; rather they grow from very sturdy taproots, and basal rosettes are present. The leaves, appearing slightly fleshy, are prominently pinnate-divided or pectinate, with lobes toothed to entire. They are broadly oblanceolate rather than oblong and are therefore closer to those of section *Rorippa*. Within section *Rorippa*, *R. microtitis*' relationship is with *R. curvisiliqua*. To the south of its range, *R. microtitis* is allied to *R. mexicana*, another transitional species. *Rorippa microtitis* not only shares characters of the two sections but also ranges between those members of each section to which it is allied.

In contrast to the *R. curvisiliqua* complex as a whole, *R. microtitis* is glabrous and has much longer petals (usually over 2.5 mm.). In pressed material, *R. microtitis* has valves flattened parallel to the replum, and they appear to be rather turgid and non-dehiscent (although old plants with mature fruits are not known); in this character the species approaches *R. curvisiliqua* var. *occidentalis*, which has straight siliques and is often glabrous. The two can readily be separated on both pedicel and petal length as pedicels in var. *occidentalis* are usually less than 2 mm. long, and petals are shorter than the sepals and no longer than 1.5 mm. In addition, var. *occidentalis* usually has spatulate to rhombic, repand to dentate leaves and the valves are often flattened perpendicular to the replum in pressed material. One interesting variation within *R. microtitis* is that, in the northern part of its range, in Arizona, the mature lower pedicels are rather short, ca. 3.5-6 mm., whereas in the southern part, in Chihuahua, they are longer, mostly 7.5-10.5 mm.

Previous to Rollins' (1957) recognition of the species, specimens of *R. microtitis* were unidentified or misidentified. He cited specimens only from Chihuahua. Kearney and Peebles (1951) reported this species from Arizona under the name *R. curvisiliqua*, expressing doubt in so referring the plants —the capsules were longer, more slender, and less curved than most specimens of *R. curvisiliqua* from the Pacific coast states. The collection of *R. microtitis* from the Mogollon Mountains in New Mexico was reported incorrectly as *Radicula sylvestris* by Wooton and Standley (1915). I have seen no material of *R. sylvestris* from New Mexico and Arizona (Stuckey, 1966b). Morphologically *R. microtitis* is very similar to *R. sylvestris*. The two, difficult to separate, represent a good example of parallel evolution. Distinguishing characters are given in the discussion of *R. sylvestris*.

DISTRIBUTION: Map 6, 7.

Rorippa microtitis grows along shores, creeks, and ditches in mountains of Arizona, New Mexico, and Chihuahua from 1700 to 2250 meters. Map 7 shows the distribution of *R. microtitis* in Arizona and New Mexico; to it has been added the 16-inch annual rainfall line. Perhaps rainfall has been a factor in bringing about isolation of *R. microtitis* from its relatives *R. curvisiliqua* and *R. sinuata*—the intermediates having since died out where they once would have occurred in the now drier outlying areas north and west.

10. RORIPPA MEXICANA (Mociño, Sessé, et Cervantes ex A. P. DeCandolle) Standley et Steyermark, Field Mus. Publ. Bot. [Fieldiana Bot.] 23: 54. 1944.

Nasturtium mexicanum Mociño, Sessé, et Cervantes ex A. P. DeCandolle, Syst. Nat. 2: 193. 1821. Cf. also A. P. DeCandolle, Calques des Dessins de la Flore du Mexique, de Mociño et Sessé, pl. 18. 1874. ("Hab[itat] in Mexico ad rivulorum margines." According to Rollins (1960), "This original label of the holotype bears the number 15-2 and the name *Sisymbrium amphibium*. There is no other information except the later assigned number 3351. The holotype compares favorably with a tracing of the original illustration cited by DeCandolle at the time of the first publication . . ." Specimen at MA. Tracing of the original illustration, GH., US!)

Nasturtium plebejum Polakowsky, Linnaea 41: 546. 1877. ("In via ferrea prope San José . . . (Nr. 534 coll.)" Holotype: COSTA RICA: PROV. SAN JOSE: Eisenbahnd. b. V. J. Jenseits d. Schienen., Nov 1875, *H. Polakowsky 534*, presumably at B. Isotype, BM! Photo at MICH! OS!)

Cardamine indica (Linnaeus) O. Kuntze δ *tanacetifolia* (Walter) O. Kuntze 2. *plebeja* (Polakowsky) O. Kuntze, Rev. Gen. 1: 24. 1891.

Cardamine palustris ("Leysser" [Linnaeus] O. Kuntze δ *mexicana* (A. P. DeCandolle) O. Kuntze, Rev. Gen. 1: 25. 1891.

Radicula mexicana (Mociño, Sessé, et Cervantes ex A. P. DeCandolle) Standley, Jour. Wash. Acad. 15: 458. 1925.

Glabrous annual, possibly a short-lived perennial; stems 0.5-3 dm. long, decumbent to prostrate, single or much branched from the base; basal and cauline leaves short-petiolate, non-auriculate, non-clasping, broadly oblanceolate to oblong, 4-8 cm. long, 0.7-1.6 cm. wide, pinnatifid to pectinate, divided to the midrib, the middle lobes oblong to elliptic, 2-7(10) mm. long, 1-4 mm. wide, their margins entire to minutely toothed, the terminal lobe narrow, rounded at the apex; racemes lateral, 0.5-1(1.5) dm. long, developing during stem elongation in the axils of the lower leaves and progressing upward, without the formation of a true terminal raceme, the oldest siliques therefore on the lower axillary racemes; pedicels (1.5)2.4-5.4(8.5) mm. long, divergent to recurved; sepals ovate to oblong, 1.4-2.1 mm. long, 0.6-1 mm. wide, flat, caducous in fruit; petals oblanceolate to spatulate, 1.7-2.6 mm. long, 0.4-0.9 mm. wide, as much as 0.5 mm. longer than the sepals; siliques elongate-cylindrical, slightly curved upward toward the raceme axis, obtuse below and not at all or only slightly tapering toward the apex, (4.2)5.5-12.5-(16.5) mm. long, (1)1.4-2.9 mm. wide, ca. 2.5-5.5(6.6) times as long as wide, ca. 1.3-3.7 times longer than the pedicels, the valves glabrous; replum oblong, the margin straight to concave; style (0.2)0.5-1.2 mm. long, ca. 0.3-0.4 mm. wide in fruit, straight to expanded below the stigma, gradually merging into the acute silique apex; stigma unexpanded to expanded in fruit; seeds regularly cordiform, ca. 0.7-0.8 mm. long, ca. 70-100 per silique, the surface light brown, coarsely colliculate; flowering and fruiting May-

October in Mexico, year around in Central America.

Rorippa mexicana is also transitional between certain species of the two sections. It is allied with *Sinuatae* in having petals longer than the sepals, but in absolute length the petals (ca. 1.7-2.6 mm. long) are shorter than in any member of *Sinuatae*. Within *R. mexicana* both anther types are developed. In the northern part of its range (Chihuahua), close to members of *Sinuatae* and *R. microtitis*, the anthers are elongate, (ca. 0.6-0.7 mm. long), twice as long as wide, but are entire at the apex; in the southern part (Guatemala and Costa Rica) they are globose to subglobose (ca. 0.2-0.3 mm. long), slightly longer than wide, and slightly notched at the apex. Geographically between these extremes (Durango) the anthers are intermediate (ca. 0.5 mm. long).

To the north, *R. mexicana* is related to *Sinuatae* via *R. microtitis*, which has elongate, apiculate anthers and petals longer than the sepals. It is also very similar to *R. microtitis* in being glabrous and having similar leaves, but differs in recurved pedicels, shorter petals, style in fruit expanded below the stigma, shorter siliques with the oldest on the lower axillary racemes, and decumbent growth. To the south it is related to a segregate of section *Rorippa* primarily distributed on the Coastal Plain and in the West Indies, especially to *R. teres*.

Rollins (1960) clarified nomenclature in *R. mexicana* with respect to the Sessé and Mociño material. In interpreting this taxon I have been guided by his annotations and a tracing and photograph of the original illustration (US).

Examination of an isotype of *N. plebejum* shows that it belongs to *R. mexicana*. Its petals are ca. 2 mm. long (longer than the sepals), the lobes of the leaves are up to 3 mm. wide, not 5 mm. wide as given by Polakowsky (1877), and the seeds are less than 6 mm. long. The pedicel, silique, style, and anther characters are also those of *R. mexicana*. When Polakowsky described *N. plebejum*, he identified another of his collections (*48*) as *N. mexicanum*; it is *R. megasperma*.

It is evident, from the description and specimens cited by Schulz (1933), that he was guided by Polakowsky's determinations. Schulz's interpretation of *N. mexicanum* was a plant with petals ca. 0.6 mm. long (shorter than the sepals), siliques 4-8 mm. long, seeds ca. 0.75 mm. long, and leaves with wide lobes. He cited Polakowsky *48* and specimens which correctly are *R. megasperma* or *R. pinnata*, species he did not distinguish. Schulz's treatment of *N. plebejum* was based on plants with petals over 1.2 mm. long (longer than the sepals), siliques 5-9 mm. long, seeds ca. 0.6 mm. long, and leaves with narrow lobes. He cited Polakowsky *534* and specimens which properly are *R. mexicana* and *R. teres*.

DISTRIBUTION: Map 8; 20-I.

Morphological data suggest that *R. mexicana* originated in uplands of northern Mexico and migrated south through these uplands, reaching as far as central Costa Rica. The species grows at elevations from ca. 600-2000(2600) meters in moist or wet sand or gravel along streams, pastures or cultivated fields, meadows of volcanoes, and often as a weed in gardens, streets, and waste ground. Its association with artificially disturbed habitats appears to be more common in Guatemala and Costa Rica.

11. RORIPPA TERES (Michaux) Stuckey, Sida 2: 409. 1966.

Cardamine teres Michaux, Fl. Bor. Am. 2: 29. 1803. ("Hab[itat] in Nova Anglica." Holotype: "Etat de Vermont Lac Champlain," *s.d.*, [*A. Michaux s.n.*], P. Photo at GH! Isotype, GH!)

Sisymbrium tanacetifolium? [sensu] Walter, Fl. Carol. 174. 1788. Non Linnaeus 1753.

Nasturtium palustre ("Leysser" [Linnaeus]) A. P. DeCandolle δ *?tanacetifolium* (Walter) A. P. DeCandolle, Syst. Nat. 2: 192. 1821.

Sisymbrium walteri Elliott, Sketch 2: 145. 1824.

Erysimum walteri (Elliott) Eaton, Man. Bot. N. Am. ed. 5, 213. 1829.

Nasturtium tanacetifolium ("Walter") Hooker et Arnott, Hook. Jour. Bot. 1: 190. 1834.

Nasturtium micropetalum Fischer et Meyer, Ind. Sem. Hort. Petrop. 3: 41. 1837. ("Hab[itat] in Americae septentrionalis provincia New Orleans dicta . . ." Type not seen.)

Nasturtium obtusum Nuttall in Torrey et Gray, Fl. N. Am. 1: 74. 1838. ("Banks of the Mississipsi [sic] [River]." Holotype: LOUISIANA: [Jefferson Parish]: In abundance in the borders of a cultivated field on the western side of the Mississippi [River]—opposite the city of N[ew] Orleans, 2 Mar *s.d.*, *H[enry] Little s.n.*, PH! Photo at MICH! OS! Sida 2: 412. 1966.)

Sisymbrium? teres (Michaux) Torrey et Gray, Fl. N. Am. 1: 93. 1838.

Nasturtium walteri (Elliott) Wood, Class Book. 228. 1861.

Cardamine indica (Linnaeus) O. Kuntze δ *tanacetifolia* ("Walter") O. Kuntze, Rev. Gen. 1: 24. 1891.

Cardamine palustris ("Leysser" [Linnaeus]) O. Kuntze α *brevipes* (A. P. DeCandolle) O. Kuntze 2. *obtusa* (Nuttall in Torrey et Gray) O. Kuntze, Rev. Gen. 1: 24. 1891.

Roripa [sic] *obtusa* (Nuttall in Torrey et Gray) Britton, Mem. Torrey Club 5: 169. 1894.

Roripa [sic] *tanacetifolia* ("Walter") Heller, Contr. Herb. Franklin & Marshall College 1: 40. 1895.

Roripa [sic] *walteri* (Elliott) Mohr, Bull. Torrey Club 24: 23. 1897.

Radicula obtusa (Nuttall in Torrey et Gray) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Radicula walteri (Elliott) Greene, Leafl. Bot. Obs. & Crit. 1: 114. 1905.

Nasturtium plebejum Polakowsky f. *latifolia* O. E. Schulz, Repert. Sp. Nov. 34: 133. 1933. ("Mexico: chiefly in the valley of the Rio Grande, below Donana C. C. Parry, J. M. Bigelow, Charles Wright, A. Schott in Mexic[an] Boundary Survey, under the direction of Major W. H. Emory." Holotype: Presumably at B. In addition to the printed data on the labels as cited by Schulz, I find isotypes as follows:

[Probably TEXAS: Maverick Co.]: Near Eagle Pass, s.d., *[J. M.] Bigelow 27*, NY! US! Photo of NY specimen at MICH! OS!)

Fall and spring annual, possibly a biennial; stems 1-4 dm. long, decumbent or prostrate, occasionally erect, single to much branched from the base, glabrous throughout or moderately covered with hemispherical obovate, to clavate vesicular trichomes; basal and lower cauline leaves short-petiolate, slightly auriculate to non-auriculate, non-clasping, oblong, oblanceolate, to broadly oblanceolate, (2)4-11 cm. long, 1-3.5(5) cm. wide, pinnately divided to the midrib, lower surface glabrous, upper surface glabrous or with hemispherical, obovate, or clavate vesicular trichomes; the middle lobes oblong to elliptic, 4-15(25) mm. long, (0.2)1-10(15) mm. wide, their margins minutely to deeply toothed, the terminal lobe narrow, obtuse to acute at the apex; racemes lateral, 0.5-2(3) dm. long, developing during stem elongation in the axils of the lower leaves and progressing upward, without the formation of a true terminal raceme, the oldest siliques therefore on the lower axillary racemes; pedicels (1.4)2.5-4.5(5.2) mm. long, ascending, glabrous or rough with hyaline ridges or vesicular trichomes; sepals ovate, oblong or oblanceolate, 1.7-2.6 mm. long, 0.6-1 mm. wide, flat to slightly saccate, caducous in fruit; petals spatulate, 1-1.7(2) mm. long, 0.4-0.6 mm. wide, slightly longer than, equal to, or as much as 0.6 mm. shorter than the sepals; siliques elongate-cylindrical, straight to slightly curved upward toward the raceme axis, acute to somewhat cuneate below, slightly tapering toward the apex, (5.2)8.5-12.5(20.4) mm. long, (0.6)1-2.2 mm. wide, ca. (4)6-9(10) times as long as wide, ca. (2)3-6(7) times as long as the pedicels, the valves smooth to rough with minute hyaline ridges or with hemispherical vesicular trichomes; replum narrowly oblong to linear, the margin straight to concave and glabrous or sparingly with vesicular trichomes; style (0.3)0.5-1.5 mm. long, ca. 0.3-0.5 mm. wide in fruit, straight to expanded below the stigma, gradually merging into the acute silique apex; stigma unexpanded to expanded in fruit; seeds regularly cordiform, ca. 0.4-0.5 mm. long, ca. 100-150 per silique, the surface dark reddish brown, deeply or shallowly foveolate; flowering and fruiting December-May and rarely at other times.

The typical variety of *R. teres* is distinctive with its somewhat obovate to clavate vesicular trichomes on the lower portion of the stems and on the upper surface of the basal and lower cauline leaves and minute (ca. 0.4-0.5 mm. long) cordiform seeds with a dark reddish brown, foveolate coat. Its closest morphological relationship is with *R. portoricensis* of the West Indies. Rollins (1960) stated that *R. teres* and *R. mexicana* are related; the two are similar in that the oldest racemes are in the lower leaf axils and the styles in fruit are expanded below the stigma, more strongly so in *R. teres*. In addition, *R. teres* has ascending and somewhat shorter pedicels, smaller petals slightly longer to considerably shorter than the sepals, and often wider leaf lobes, which separate it from *R. mexicana*.

Plants of the typical variety of *R. teres* from Mexico and the western part of its range in the United States show a tendency for long petals (ca. 1.5-2 mm.) and long siliques (ca. 9-17 mm.), whereas in the eastern part of its range the petals and siliques often are shorter (ca. 1-1.5 mm. and ca. 5-9 mm., respectively).

For a detailed discussion of the nomenclatural history, see Stuckey (1966c).

DISTRIBUTION: Map 8; 20-J.

Rorippa teres is distributed on the southern portion of the Atlantic and throughout the Gulf Coastal Plain of the United States. The species is disjunct from the Rio Grande to southern Veracruz, where it is known sparingly there and southward near the coast. It recurs on the Coastal Plain of western Mexico. Morphological and geographical data suggest an origin in the Mexican uplands from a plant much like *R. mexicana*, evolutionarily diverging into two slightly morphologically different populations, with one migrating onto the Mexican Coastal Plain to the west and the other one migrating in two directions, one toward Veracruz and southward and the other northeastward across Texas and onto the Gulf Coastal Plain sometime during the late Tertiary and early Quaternary periods. The tendency toward shorter petals and siliques in the eastern portion of its range in the United States further suggests this history.

Key to Varieties of Rorippa teres

1. Vesicular trichomes present on the lower portion of the stem and upper surface of basal and lower cauline leaves; siliques and pedicels glabrous, smooth or slightly rough with minute hyaline ridges; seeds prominently deeply pitted; southern Atlantic and Gulf Coastal Plain of the United States and Mexico. . . . . 11a. *var. teres*
1. Vesicular trichomes absent from the lower portion of the stem and upper surface of basal and lower cauline leaves; siliques and pedicels with vesicular trichomes; seeds inconspicuously shallowly pitted; western coast of Mexico and the east coast of Honduras and Nicaragua. . . . . 11b. var. *rollinsii*

11a. RORIPPA TERES (Michaux) Stuckey var. TERES

ILLUSTRATIONS: Gleason (1952, p. 241), as *R. obtusa*—stem, racemes, and siliques, and the long silique to the left; Small (1933, p. 557), as *Radicula walteri*—petals slightly longer than sepals (only flowering and fruiting parts are shown); Stuckey (1966c, p. 412), photograph of a portion of the holotype of *Nasturtium obtusum.*

The synonymy for the typical variety is presented before the description of the species.

DISTRIBUTION: Map 8.

11b. RORIPPA TERES (Michaux) Stuckey var. **rollinsii** Stuckey, var. nov.

(Holotype: MEXICO: SINALOA: Sandy field, vicinity of Fuerte, 27

Mar 1910, *J. N. Rose, P. C. Standley, P. G. Russell 13599*, US! Photo at MICH!, Fig. 5. Isotypes, MO! NY!)

Herba annua decumbens; caulibus foliisque glabris; siliquis pedicellisque vesiculo-pubescentibus; seminibus superficialiter foveolatis.

ILLUSTRATION: Fig. 5.

Rollins (1961) pointed out some differences between plants of *R. teres* of the United States and eastern Mexico and those of the west coast of Mexico and suggested that with additional knowledge there might well be recognition of a new taxon. The segregates are geographically isolated, although one collection of var. *teres* is known from the west coast of Mexico: Manzanillo, Colima, Palmer *1344* (US). It appears to be out of its natural range. Rollins (1961) wrote that "it is possible that *R. walteri* [*R. teres*] has been carried by man somewhat outside of its natural range in Mexico and Central America because it is used as a salad plant, and may be seen in the local markets of western Mexico." There is no indication of such distribution in Rose's (1895) report on Palmer's collections. I refer specimens from Nicaragua and Honduras to var. *rollinsii* with hesitation. In addition to having trichomes on the valves and pedicels, these plants have trichomes on the upper surface of the lower cauline and basal leaves and on the lower portion of the stem. The siliques are more straight and erect and, with the leaves, take on the appearance of those of *R. portoricensis*. In fact, Standley (1931) considered the Honduran plant to belong to the West Indian species.

DISTRIBUTION: Map 8.

12. RORIPPA PORTORICENSIS (Sprengel) Stehlé, Revue Bot. Appl. Agr. Trop. 26: 103. 1946.

Nasturtium portoricense Sprengel, Syst. 2: 882. 1825. ("Portorico. Hispaniola. Bertero." Type not seen.).

Nasturtium palustre ("Leysser" [Linnaeus]) A. P. DeCandolle ?*brevipes* A. P. DeCandolle, Syst. Nat. 2: 192. 1821. ("quam in Porto-Ricco [sic] ad vias locis inundatis exsiccatisque legit cl. Bertero," Holotype: PUERTO RICO: PONCE: Porto Ricco, Apr 1820, *Balbis* [Bertero was the collector, *fide* Urban (1902, p. 19)] *s.n.*, G-DC. Microfiche 1:137.4, card no. 63, MICH!)

Nasturtium brevipes (A. P. DeCandolle) Grisebach, Mem. Am. Acad. n.s. 8: 154. 1861. (When Grisebach made this combination, he had the following collection: CUBA: [ORIENTE]: In Cuba Orientali, ["In humidis ad vias prope Santa Catalina de Guantanamo, Jan-Feb," (Grisebach, 1861, p. 154)] 1860, *C. Wright 1562*. This material later became the type of *Nasturtium brevipes* (A. P. DeCandolle) Grisebach var. *pumilum* O. E. Schulz.)

Cardamine palustris ("Leysser" [Linnaeus]) O. Kuntze α *brevipes* (A. P. DeCandolle) O. Kuntze, Rev. Gen. 1: 24. 1891.

Nasturtium tanacetifolium Hooker et Arnott var. *insularum* S. Watson in Gray, Syn. Fl. N. Am. 1: 149. 1895. [Substitute name proposed for

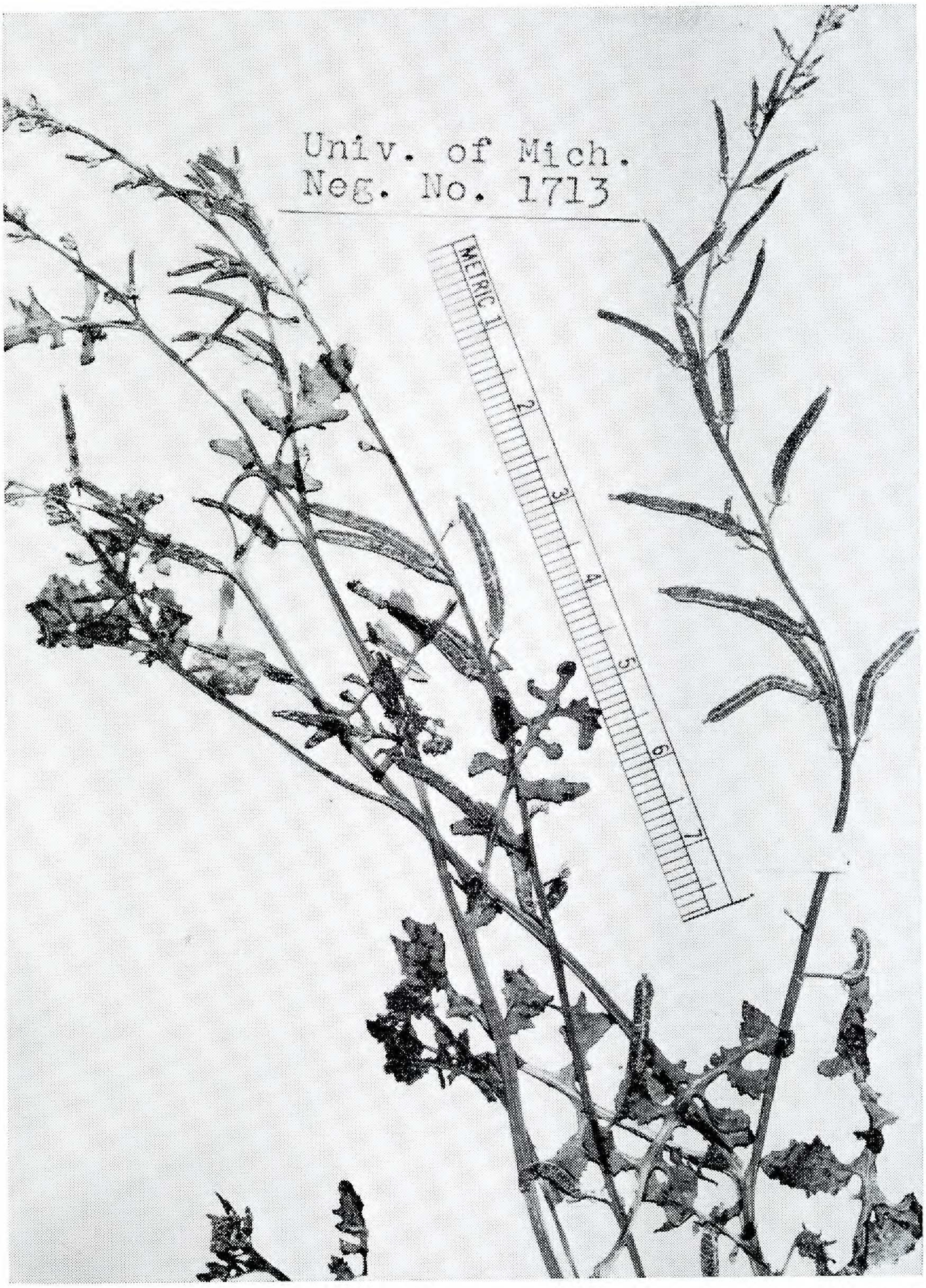


Fig. 5. Photograph of a portion of an isotype of *Rorippa teres* (Michaux) Stuckey var. *rollinsii* Stuckey. (*J.N. Rose, P.C. Standley, P.G. Russell 13599*, MO). Univ. Mich. Neg. No. 1713.

Nasturtium brevipes (A. P. DeCandolle) Grisebach]

Radicula brevipes (A. P. DeCandolle) Britton, Torreya 6: 30. 1906.

Radicula portoricensis (Sprengel) Britton, Sci. Surv. Porto Rico & Virgin Isl. 5: 328. 1924.

Fall and spring annual, possibly a biennial; stems 0.5-3.5 dm. long, decumbent or prostrate, occasionally erect, single to much branched from the base, glabrous throughout or moderately covered with hemispherical vesicular trichomes below; basal and lower cauline leaves short-petiolate, slightly auriculate to non-auriculate, non-clasping, oblong to oblanceolate, 2-10 cm. long, 1-1.5(2.2) cm. wide, pinnately divided nearly to the midrib, lower surface glabrous, upper surface glabrous or with vesicular trichomes, the middle lobes oblong to elliptic, 3-7(15) mm. long, 2-5(10) mm. wide, their margins entire, deeply crenate to angularly toothed, the terminal lobe narrow to broad, rounded at the apex; racemes lateral, 0.5-1.5(2) dm. long, developing during stem elongation in the axils of the lower leaves and progressing upward without the formation of a true terminal raceme, the oldest siliques therefore on the lower axillary racemes; pedicels (0.6)1-2.2(3) mm. long, ascending, glabrous or rough with hyaline ridges or vesicular trichomes; sepals ovate to oblong, 1-1.5 mm. long, 0.3-0.5 mm. wide, the outer ones saccate, the inner ones flat, caducous in fruit; petals absent or present and oblong to narrowly spatulate, 0.8-1.2 mm. long, 0.2-0.4 mm. wide, as much as 0.3 mm. shorter than the sepals; siliques elongate-cylindrical, straight, obtuse to somewhat acute below, not at all or only slightly tapering toward the apex, (3)4.5-9(12) mm. long, 1.2-1.8 mm. wide, ca. 3-5 times as long as wide, ca. (2)3-7(9) times as long as the pedicels, the valves smooth to rough with hyaline ridges or hemispherical vesicular trichomes throughout or only on the edges; replum narrowly oblong, the margin straight and glabrous or with sparse vesicular trichomes; style absent to 0.5 mm. long, straight to expanded below the stigma, gradually merging into the obtuse to somewhat acute silique apex; stigma expanded in fruit; seeds regularly cordiform, ca. 0.4-0.6 mm. long, ca. 50-100 per silique, the surface dark reddish-brown, somewhat reticulate to shallowly foveolate; flowering and fruiting (November)January-April.

Rorippa portoricensis is unique in that petals may be present or absent, even on the same plant. Rollins (1961) pointed out that the relationship between *R. walteri* [*R. teres*] and *R. portoricensis* is very close and that whether to maintain them as two species or as varieties of one species is uncertain. The basic differences are the shorter more slender styles and pedicels in fruit of *R. portoricensis*. *Rorippa portoricensis* tends to have shorter, somewhat straighter siliques, and the margins of the leaf-lobe margins more crenately divided rather than sharply toothed. The seeds of *R. portoricensis* are shallowly pitted to somewhat reticulate, like those of *R. teres* var. *rollinsii* but different from the deeply pitted ones of var. *teres*.

DISTRIBUTION: Map 8; 20-K.

A stream and river bank plant, *R. portoricensis* is endemic to the West Indies: Bahama Islands (Andros), Cuba, Puerto Rico, and Dominican Republic. Within *R. portoricensis*, as in *R. teres*, there are slight divergences in morphology and trichome distribution in geographically segregated plants.

Key to Varieties of Rorippa portoricensis

1. Vesicular trichomes absent from the lower portion of the stem, and basal and lower cauline leaves; stigma sessile, rarely on style up to 0.5 mm. long; siliques (4.5)7-11(12) mm. long; Puerto Rico and the Dominican Republic. . . . . 12a. var. *portoricensis*
1. Vesicular trichomes present on the lower portion of the stem and the upper surface of basal and lower cauline leaves; stigma on a style up to 0.5 mm. long, rarely sessile; siliques (3)4.5-8(9) mm. long; Cuba and on Andros in the Bahama Islands. . . . . 12b. var. *pumilum*

12a. RORIPPA PORTORICENSIS (Sprengel) Stehlé var. PORTORICENSIS

The synonymy for the nomenclatural typical variety is presented before the description of the species.

DISTRIBUTION: Map 8.

12b. RORIPPA PORTORICENSIS (Sprengel) Stehlé var. **pumilum** (O. E. Schulz) Stuckey, comb. nov.

Nasturtium brevipes (A. P. DeCandolle) Grisebach var. *pumilum* O. E. Schulz, Symb. Antill. 3: 517. 1903. ("Hab[itat] in Cuba: Wright n. 1562, in Yumury valle: Rugel n. 235." Lectotype: CUBA: [ORIENTE]: In Cuba Orientali, ["In humidis ad vias prope Santa Catalina de Guantanamo, Jan-Feb," (Grisebach, Mem. Am. Acad. n. ser. 8: 154. 1861] 1860, *Charles Wright 1562*, presumably at B. Isolectotypes, GH! MO! NY! PH! US! Photo of MO specimen at MICH! OS!)

Nasturtium brevipes (A. P. DeCandolle) Grisebach var. *jackianum* O. E. Schulz, Repert. Sp. Nov. 34: 135. 1933. (Holotype: CUBA: SANTA CLARA: On shore of Arimao River, Vega, Soledad, Cienfuegos, 20 Mar 1930, *J. G. Jack 7805*, presumably at B. Isotype, US!)

DISTRIBUTION: Map 8.

13. RORIPPA SESSILIFLORA (Nuttall in Torrey et Gray) A. S. Hitchcock, Spring Fl. Manhattan 18. 1894.

Nasturtium sessiliflorum Nuttall in Torrey et Gray, Fl. N. Am. 1: 73. 1838. ("Banks of the Mississippi [River]." Holotype: [?ARKANSAS: county unknown]: Arkansas, [ca. 1819, *fide* Pennell (Bartonia 18: 27-28. 1936), *Thomas Nuttall s.n.*], BM. Neg. no. BM 2129, BM. Isotype, Mississippi [River], PH! Photo at MICH!, OS! [The specimens were originally labeled "Nasturtium *sessiliflorum S. amphibium affine fruit subsess."])

Nasturtium limosum Nuttall in Torrey et Gray, Fl. N. Am. 1: 74. 1838. ("Banks of the Mississippi [River], near New Orleans." Holotype:

LOUISIANA: [Orleans Parish]: Near the bank of the [Mississippi] River below the city, N[ew] Orleans, 24 Feb *s.d.*, *H[enry] Little s.n.*, PH! Photo at MICH!, OS! [The specimen was originally labeled "N[asturtium] *limosum" by Nuttall. No duplicate was found at BM by Dr. Rogers McVaugh.])

Cardamine palustris ("Leysser" [Linnaeus] O. Kuntze α *brevipes* (A. P. DeCandolle) O. Kuntze 1. *sessiliflora* (Nuttall in Torrey et Gray) O. Kuntze, Rev. Gen. 1: 24. 1891.

Radicula sessiflora [sic] (Nuttall in Torrey et Gray) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Radicula limosa (Nuttall in Torrey et Gray) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Glabrous summer, fall, or winter annual, possibly a biennial; stems (1)2-5 dm. tall, erect, single to much branched from the base; basal and lower cauline leaves short-petiolate to cuneate and sessile, slightly auriculate to non-auriculate, non-clasping, oblong, obovate, oblanceolate, to spatulate, 1.5-6(11) cm. long, (0.5)1-2(4) cm. wide, the margins entire, crenate, irregularly serrate, to repand, broadly obtuse to somewhat acute at the apex; racemes terminal and axillary, ca. 0.5-1(2) dm. long, forming during stem elongation, the siliques therefore nearly equal in age at corresponding points on the racemes; pedicels 0.5-1.5(2) mm. long, ascending, smooth to rough with hyaline ridges; sepals ovate to lanceolate, 1.3-2 mm. long, 0.4-0.8 mm. wide, strongly saccate, caducous in fruit; petals absent; siliques elongate cylindrical, straight to slightly curved inward toward the raceme axis, acute to cuneate below and becoming slightly wider toward the apex, (3)5.4-8.5(10.2) mm. long, (1.4)1.8-2.6(3.3) mm. wide, ca. 3-5 times as long as wide, ca. (4)6-9 times as long as the pedicels, the valves smooth to rough with minute hyaline ridges; replum oblong to slightly obovate in outline, the margin straight to concave and glabrous; style absent to 0.4 mm. long, ca. 0.3-0.5 mm. wide in fruit, strongly expanded below the stigma, occasionally straight, gradually merging into the obtuse silique apex; stigma expanded in fruit; seeds regularly cordiform, ca. 0.4-0.5 mm. long, ca. 150-200 per silique, the surface light yellowish-brown, deeply foveolate; flowering and fruiting March-October.

ILLUSTRATIONS: Britton & Brown (1897, p. 126, fig. 1720; 1913, p. 162, fig. 2032); Fassett (1940, p. 232, fig. 12, 13), plant & seed; Gleason (1952, p. 241); Gray (1849a, p. 132, pl. 53, fig. 6-8), entire plant—an excellent drawing!; Murley (1951, p. 72, fig. 24), seed; Steyermark (1963, p. 759, pl. 185, no. 2).

Rorippa sessiliflora is one of the most distinctive of North American *Rorippa*. The siliques are very thick, often over 2 mm. wide, obliquely wedge-shaped at the base, and on very short (0.5-1.5 mm.) pedicels. More striking is the absence of petals. Stamens are 3 to 6, even in different flowers on a plant, and sometimes the filaments are fused. The extremely small (to 0.5 mm. long), numerous (ca. 150-200 per silique), light yellowish-brown seeds are deeply pitted.

The species is most closely related to *R. teres* and *R. portoricensis*. This alliance is suggested by very small numerous seeds, short styles expanded below the stigma, short pedicels, tiny flowers, and often rough valves with minute hyaline ridges. The very short pedicels and styles and absence of petals recall *R. portoricensis*; style shape, the deeply pitted seeds, and the cuneate-based siliques recall *R. teres*. *Rorippa sessiliflora* differs from *R. teres* and *R. portoricensis* in growth habit, in being glabrous, and in having strongly saccate sepals and obovate to oblanceolate entire, repand, or somewhat toothed leaves.

The type of Nuttall's *Nasturtium limosum* is an extreme variation within *R. sessiliflora* in having basal and cauline leaves lacinate-divided to coarsely toothed on the upper portion of the plant, leaf apex acute, and longer pedicels (1.5)1.8-3.2 mm. long. In addition to the type of *N. limosum*, five similar specimens are known (ILLINOIS: Alexander Co., *Palmer 14898*, PH, MO; Bellville, May 1835, *Engelmann s.n.*, MO; Sangamon Co., *Stearns 270*, WIS. MISSOURI: St. Louis Co., *Muehlenbach 1498*, MO, OS. TEXAS: Smith Co., *Kral 627*, FSU.) These may be shade forms of *R. sessiliflora*. Plants grown in the greenhouse from seed of my *1604* from Schuyler County, Illinois, when cultivated during winter (short days), had basal leaves much more dissected and acute at the tip than did plants collected in the field or grown in the greenhouse during summer (long days). Some herbarium specimens from Arkansas also have leaves of this type. These variants may also represent occasional natural hybrids between *R. sessiliflora* and *R. palustris* var. *fernaldiana*, the ranges and habitats of which overlap. In seven of nine localities where I found *R. sessiliflora* with *R. palustris* var. *fernaldiana*, I did not find this extreme variant or any plant suggesting a hybrid between the two taxa.

DISTRIBUTION: Map 9; 20-L.

Rorippa sessiliflora is the only species of *Rorippa* confined to central United States in the Mississippi embayment, extending northward to the southern limit of Wisconsin glaciation, and occurring sparingly in southeastern United States. It inhabits muddy places along rivers, streams, creeks, and ponds and in low wet fields. Most specimens are from localities along rivers and streams of the Mississippi embayment. The seeds germinate in open, moist bare sand or mud, and because the water level may fluctuate during the season, plants in all stages of vegetative growth, flowering, and fruit maturation may be found at a locality throughout the growing period. This behavior, though found in other species, appears to be most common in *R. sessiliflora*, largely because of its frequent and close association with rivers and streams. The seeds float and are easily dispersed. I placed seeds in water 10 December 1964; they floated until 10 February 1965.

The limitation of *R. sessiliflora* on the north by the southern limit of Wisconsin glaciation is striking. Its occasional occurrence in glaciated territory is not surprising since the species could have been spread northward by agricultural practices. Over (1932) listed it as "sparingly in old creek beds" from South Dakota. I have not seen specimens from South Dakota, but the species would be expected in the state's southeastern corner. Strausbaugh and Core (1953) do not have it from West Virginia; it is probably absent from this mountainous region. Harris (1958) reported *R. sessiliflora* from Essex County, Massachusetts; the collection was made in 1859, "a weed in garden and seen there for many years past" (PM). I have not seen the specimen. If correctly identified, it doubtless is an introduction. Reports for the District of Columbia area (Hitchcock and Standley, 1919), Virginia (Massey, 1961), and Georgia (Thorne, 1954) are all apparently correct.

Summary of the species of southeastern affinity. *Rorippa teres*, *R. portoricensis*, and *R. sessiliflora* are a culmination of one line of development that probably arose from a plant in the Mexican uplands similar to *R. mexicana* and migrated onto the Coastal Plain. These three species are allied by character combinations not found in other North American *Rorippa*, most importantly the small flowers; numerous, small seeds, mostly foveolate; thick styles expanded below the stigma in fruit; and short pedicels. *Rorippa sessiliflora* is the most highly evolved member, especially with its loss of petals, extremely short pedicels, modifications in stamen number, and the most seeds per silique. Plants somewhat intermediate between *R. teres* and *R. portoricensis* indicate the close relationship of these species, but no intermediates between either of these and *R. sessiliflora* have been found. The data certainly suggest a southern origin for *R. sessiliflora* with migration northward up the river valleys of the Mississippi basin and eastward nearly to the Atlantic. Was its northward penetration halted by ice-filled river valleys, or was its northern range trimmed by the glacier? Nearly all the other native species that exhibit correlation and movement along a river system seem to show downriver migration. In contrast, *R. sessiliflora* has apparently traveled upriver.

14. RORIPPA **megasperma** Stuckey, sp. nov. (Holotype: COSTA RICA: PROV. CARTAGO: Cartago, 4250 pp, Nov 1887, *Juan J. Cooper 5708*, GH! Photo at MICH!, Fig. 6. Isotype, US!).

Glabrous fall and winter annual, possibly a biennial; stems 3-5 dm. long, decumbent to erect, simple to sparingly branched from the base, glabrous to sparingly hirsute on the lower portion; basal and lower cauline leaves short-petiolate, auriculate to non-auriculate, non-clasping, oblong to broadly oblanceolate, 5-10 cm. long, 1.8-3 cm. wide, pinnately divided to the midrib, both surfaces smooth, glabrous, the middle lobes oblong to elliptic, 5-18(22) mm. long, 3-7 mm. wide, their margins deeply crenate to angularly toothed, the terminal lobe as wide as or occasionally wider than the laterals, acute at the apex; racemes terminal and axillary, ca. 0.5-1 dm. long, forming during stem elongation, the siliques therefore nearly equal in age at corresponding points on the racemes; pedicels 2-3.7 mm. long, divergent to recurved; sepals oblong to oblanceolate, 0.8-1.6 mm. long, 0.3-0.6 mm. wide, flat to slightly saccate, caducous in fruit; petals oblong to narrowly spatulate, 0.6-1.1 mm. long, 0.2-0.4 mm. wide, as much as ca. 0.5 mm. shorter than the sepals; siliques elongate-cylindrical, slightly curved upward, obtuse below and becoming strongly clavate toward the apex, 6.7-11 mm. long, (0.8)1-1.5 mm. wide, ca. 5-8(11) times as long as wide, ca. 2-4 times as long as the pedicels, the valves smooth to slightly rough with hyaline ridges; replum narrowly oblong in outline, slightly twisted, the margin straight; style nearly absent to 0.5 mm. long, ca. 0.1-0.4 mm. wide, straight, abruptly attached to the obtuse to truncate silique apex; stigma unexpanded in fruit; seeds regularly cordiform, 0.8-1.1 mm. long, ca. 20-30 per silique, the surface light brown, coarsely colliculate; flowering and fruiting November-April(June).

Herba annua glabra; caulibus 3-5 dm. longis decumbentibus vel erectis unicis vel numerosis glabris vel sparse hirsutis; foliis radicalibus caulinisque petiolatis vel sessilibus auriculatis vel non-auriculatis oblongis vel late oblanceolatis 5-10 cm. longis, 1.8-3 cm. latis pinnatilobatis; pedicellis 2-3.7 mm. longis diversis vel recurvatis; sepalis oblongis vel oblanceolatis 0.8-1.6 mm. longis, 0.3-0.6 mm. latis planis; petalis flavis oblongis vel anguste spathulatis 0.6-1.1 mm. longis, 0.2-0.4 mm. latis; siliquis elongato-cylindricis clavatis 6.7-11 mm. longis, (0.8)1-1.5 mm. latis; stylis fere absentibus vel 0.5 mm. longis; seminibus cordiformibus colliculatis 0.8-1.1 mm. longis.

ILLUSTRATION: Fig. 6.

Rorippa megasperma is a glabrous plant with pinnately divided leaves. The seeds, coarsely colliculate, usually are over 0.8 mm. long and are the largest among the species in this alliance. Another distinguishing feature of *R. megasperma* is its long fruits, usually clavate at the apex, 2-4 times as long as the pedicels. The silique surface is often undulate with ridges and depressions formed by close contact of the valves with the seeds. This species is most closely related to *R. pinnata* and *R. intermedia.*

DISTRIBUTION: Map 10; 20-M.

Rorippa megasperma is known from four localities in the mountains of central Costa Rica and from one in Guatemala. Its northern limit is obscure. More collections are needed from Central America to clarify the ranges of various *Rorippa* species there.

15. RORIPPA PINNATA (Sessé et Mociño) Rollins, Rhodora 62: 18. 1960.
Arabis pinnata Sessé et Mociño, La Naturaleza, ser. 2, I; appendix p. 104. 1889. ("Habitat ad margines rivulorum Quahunahuacensium." According to Rollins (1960), "The original label reads '15-2 Arabis pinnata N. Habitat ad margines rivulorum Guaunahuacae.' [Cuernavaca, state of Morelos, Mexico] The newly assigned number is 3345." Specimen at MA.)

Glabrous fall and winter annual, possibly a biennial; stems 3-6 dm. long, decumbent to erect, single to sparingly branched from the base, glabrous to moderately hirsute on the lower portion; basal and lower cauline leaves short-petiolate, auriculate to non-auriculate, non-clasping, oblong to broadly oblanceolate, 3-11 cm. long, 1.2-3 cm. wide, pinnately divided to the midrib, both surfaces smooth, glabrous, the middle lobes oblong to elliptic, (7)10-20 mm. long, 3-7 mm. wide, their margins crenate to sharply toothed,

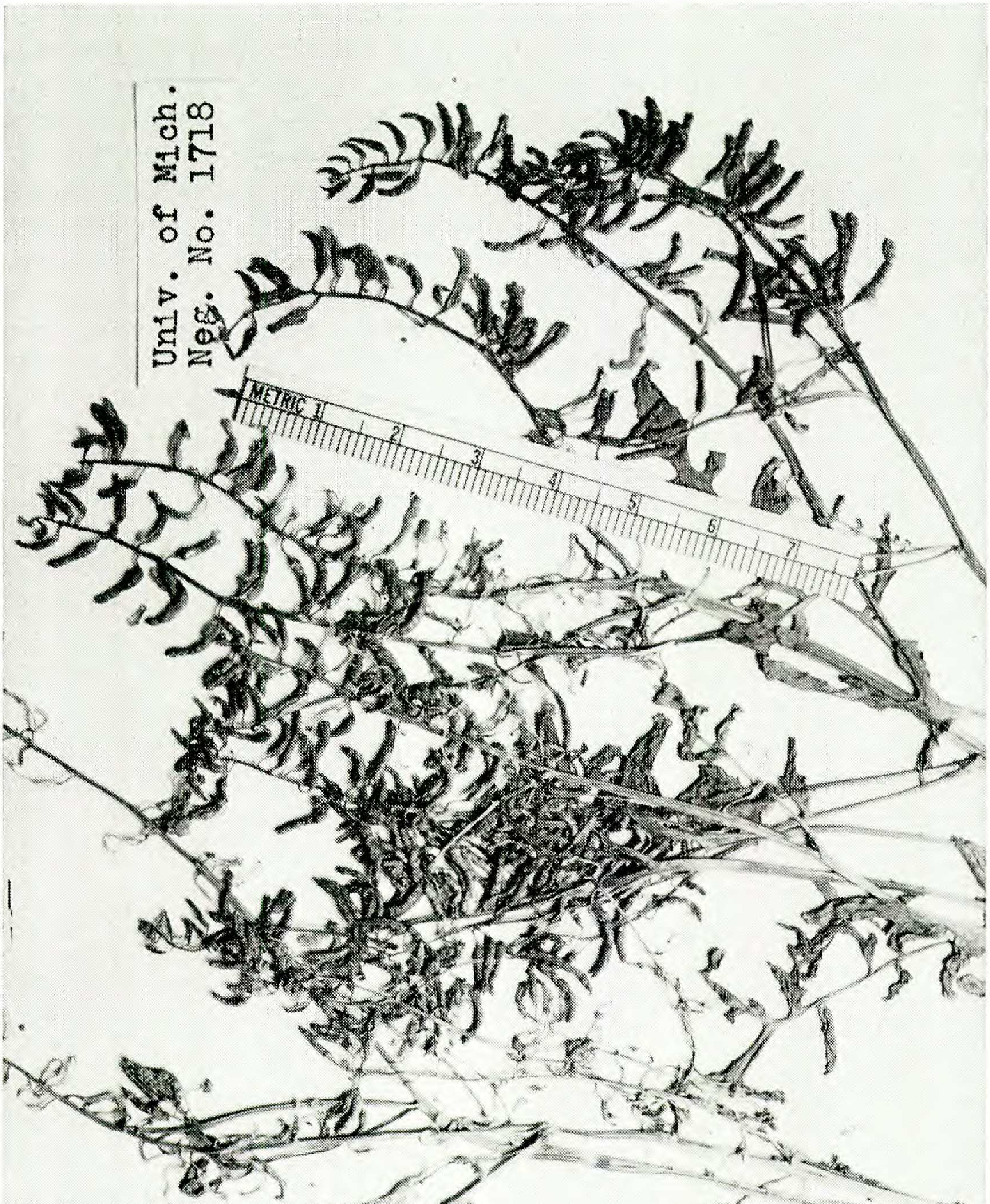


Fig. 6. Photograph of a portion of the holotype of *Rorippa megasperma* Stuckey. (*J.J. Cooper 5708*, GH). Univ. Mich. Neg. No. 1718.

the terminal lobe as wide as or wider than the laterals, obtuse at the apex; racemes terminal and axillary, ca. 0.5-1.5 dm. long, forming after or during stem elongation, the oldest siliques therefore on the lower portion of the terminal raceme or siliques nearly equal in age at corresponding points on the racemes; pedicels 2.4-4.5(5.8) mm. long, recurved; sepals broadly ovate to oblong, 0.8-1.2 mm. long, 0.5-0.8 mm. wide, flat to slightly saccate; petals oblong to narrowly spatulate, 0.5-0.7 mm. long, 0.1-0.2 mm. wide, as much as 0.5 mm. shorter than the sepals; siliques short-cylindrical, slightly curved upward, obtuse below, gradually tapering toward the apex, slightly constricted at the center, 2.8-6.5(7.4) mm. long, (1.1)1.4-2.3 mm. wide, ca. 1.5-4 times as long as wide, ca. 0.8-2 times as long as the pedicels, the valves smooth or occasionally with minute hyaline ridges; replum narrowly oblong to somewhat triangular in outline, occasionally twisted, the margin concave; style 0.1-0.5 mm. long, ca. 0.2-0.5 mm. wide, straight to slightly tapering, abruptly attached to somewhat merging into the acute, obtuse, or rarely truncate silique apex; stigma unexpanded in fruit; seeds regularly cordiform, ca. 0.7-0.8 mm. long, ca. 25-50 per silique, the surface light brown, finely colliculate; flowering and fruiting November-March.

ILLUSTRATION: Rollins (1960, p. 17).

Rorippa pinnata is a pinnate-leaved plant with usually a sparingly hirsute stem. The short, rather thick, concave-margined siliques acute at the apex and on strongly recurved pedicels distinguish it from its relatives, *R. megasperma* and *R. intermedia*.

In interpreting *R. pinnata*, I have followed Rollins (1960). All specimens he cited belong to this taxon. Schulz (1933) included specimens of *R. pinnata* under *N. mexicanum*. Previous to Rollins' work, most specimens of *R. pinnata* were undetermined or referred to *R. mexicana*.

DISTRIBUTION: Map 10; 20-N.

Apparently *R. pinnata* is a species of disjunct distribution. I have seen specimens from Colombia; from the states of México, Michoacan, Morelos, Puebla, and the Federal District of Mexico; and from Guatemala. The southern limit of its North American range is probably northern Guatemala or southern Mexico. The species apparently does not reach Costa Rica, where it is replaced by *R. megasperma*.

16. RORIPPA **intermedia** (O. Kuntze) Stuckey, comb. nov.

Cardamine palustris ("Leysser" [Linnaeus]) O. Kuntze δ *mexicana* (A. P. DeCandolle) O. Kuntze 2. *intermedia* O. Kuntze, Rev. Gen. 1: 25. 1891. ("Costarica!!" Type: COSTA RICA: PROV. CARTAGO: Cartago, *s.d.*, *Herbarium Otto Kuntze 17.74-2167*, NY! Photo at MICH! OS!) [The specimen was originally labeled "Nasturtium palustre sp[?] mexicanum (M. S.) var. intermedium n."])

Glabrous winter annual, possibly a biennial; stems 1.5-6 dm. tall, erect to occasionally decumbent, single to sparingly branched from the base, glabrous or very sparingly hirsute; basal and lower cauline leaves short-petiolate, auriculate to non-auriculate, non-clasping, oblong to broadly lanceolate, 4-10 cm. long, 1-3 cm. wide, pinnately divided to the midrib, lower surface rough with hyaline ridges on the midrib, upper surface smooth and glabrous or sparingly hirsute on the midrib, the middle lobes oblong to elliptic, (4)8-20 mm. long, (2)4-7(10) mm. wide, their margins minutely to deeply, sharply toothed, the terminal lobe as wide as the laterals, acute at the apex; racemes terminal and axillary, ca. 0.4-1 dm. long, forming after or during stem elongation, the oldest siliques therefore on the lower portion of the terminal raceme or siliques nearly equal in age at corresponding points on the racemes; pedicels 2-5.2(7) mm. long, divergent to ascending; sepals ovate to oblong, 0.7-1.6 mm. long, 0.3-0.8 mm. wide, flat to slightly saccate, caducous in fruit; petals oblong to narrowly spatulate, 0.5-1.1 mm. long, 0.1-0.4 mm. wide, as much as 0.5 mm. shorter than the sepals; siliques short-cylindrical, straight to very slightly curved upward, obtuse below and tapering toward the apex, 2.7-4.5 mm. long, 0.7-1.3 mm. wide, ca. 3-5 times as long as wide, (0.6)0.8-1.5(1.8) times as long as the pedicels, the valves smooth to somewhat rough with hyaline ridges; replum very narrowly rectangular in outline, the margin straight to slightly concave; style 0.1-0.5 mm. long, ca. 0.2-0.4 mm. wide, straight throughout, gradually merging into the somewhat abruptly attached acute silique apex; stigma unexpanded, rarely expanded in fruit; seeds ca. 0.5-0.6 mm. long, ca. 10-20 per silique, the surface brown, finely colliculate; flowering and fruiting February-April.

Rorippa intermedia is another of the pinnate-leaved members of this alliance. The very slender, short siliques, ca. 0.6-1.8 times as long as the divergent to ascending pedicels; few, small, finely colliculate seeds; and the lower leaf surface covered with hyaline ridges especially on the midrib are distinctive. To the south, *R. intermedia* is allied with *R. pinnata* and *R. megasperma*; to the north, with *R. truncata*.

Rorippa intermedia is typified by a Kuntze specimen at NY (the basis for his *Cardamine palustris* δ *mexicana* 2. *intermedia*) from Cartago, Costa Rica, that exhibits well the silique, pedicel, and petal characters of those plants from the western coastal plain of Mexico and extreme southwestern United States. However, the type differs from these plants in having narrower leaf segments. Leaf lobes in the northern plants are ca. 5 mm. or more wide; those of the type are only up to ca. 3 mm. The narrow leaf lobes suggest *R. mexicana*, but in contrast to that species, the type of *R. intermedia* has small petals shorter than the sepals, much shorter and narrower siliques, divergent to ascending pedicels, and smaller and fewer seeds.

DISTRIBUTION: Map 10; 20-0.

Rorippa intermedia is known from Costa Rica, western Mexico, and north to extreme southwestern United States and Lower California.

Summary of the pinnate-leaved species of Mexico and Central America. *Rorippa megasperma*, *R. pinnata*, and *R. intermedia* are allied by their deeply pinnate-divided basal and both upper and lower cauline leaves. The oblong to elliptic lobes mostly over 5 mm. in width have deeply crenate to sharply toothed margins. The essential differences among the three taxa are given in the key. Growth aspects are not well known in the species, and the few herbarium specimens are of little help. *Rorippa megasperma* appears to be a decumbent plant flowering and fruiting during stem elongation. Some specimens of *R. pinnata* and *R. intermedia* appear to have had the stem elongate before flower and fruit formation, much as in *R. palustris*; other specimens appear to have developed like *R. megasperma*. The strong, stout stems suggest that *R. pinnata* and *R. intermedia* grow erect or perhaps only somewhat decumbent.

I picture, for the three species, a pinnate-leaved prototype that probably arose out of the *R. curvipes* complex of western United States and extended southward as far as Costa Rica. Geographical isolation and morphological differentiation, particularly in fruit and seed size and shape, became manifest. The ultimate differentiation in this evolutionary line is reflected in *R. megasperma*, with the largest fruits and seeds of the alliance. That the three are distinct species is shown not only morphologically but also geographically. Specimens intermediate between the taxa are not known to me. Because of varying topography and the wide separation of similar habitats (e.g. lake shores) considerable endemism is to be expected in the region where the species occur.

17. RORIPPA TRUNCATA (Jepson) Stuckey, Sida 2: 414. 1966.

Radicula sinuata (Nuttall in Torrey et Gray) Greene var. *truncata* Jepson, Man. Flowering Pl. Calif. 424. 1925. (Holotype: CALIFORNIA: [Los Angeles Co.]: Crystal Lake—North Fork San Gabriel Riv[er], San Gabriel Mountains, 5500 ft, 19 Jun 1921, *Frank W. Peirson 2450*, JEPS! Photo at OS! Sida 2: 415. 1966.)

Glabrous summer and fall, rarely winter annual; stems 1-3(5) dm. long, decumbent to prostrate, much branched from the base; basal and lower cauline leaves short-petiolate, slightly auriculate to non-auriculate, non-clasping, oblong to narrowly oblanceolate, 5-12(26) cm. long, 0.8-1.6(2.5) cm. wide, pinnately divided to the midrib, lower surface smooth or occasionally with hyaline ridges on the midrib, upper surface smooth, glabrous or occasionally sparingly hirsute on the midrib, the middle lobes oblong to elliptic, 3-12(20) mm. long, 1-6(12) mm. wide, their margins entire to angularly toothed, the terminal lobe as wide or wider than the laterals, mostly obtuse at the apex; racemes lateral, 0.4-1 dm. long, developing during stem elongation in the axils of the lower leaves and progressing upward, without the formation of a true terminal raceme, the oldest siliques therefore on the lower axillary racemes; pedicels (1)1.5-3.5(4) mm. long, divergent to ascending; sepals ovate to oblong, 0.8-1.5 mm. long, 0.4-0.6 mm. wide, flat to slightly saccate, caducous in fruit; petals oblong to narrowly spatulate, 0.7-1.2 mm. long, 0.2-0.4 mm. wide, as much as 0.4 mm. shorter than the sepals; siliques short-cylindrical, straight, obtuse to broadly cuneate below and not at all or only slightly tapering toward the apex, constricted at the center, (2.3)3-5(8.2) mm. long, (0.7)1.2-2 mm. wide, ca. 2-4.2(6) times as long as wide, 1.5-2.8(6) times as long as the pedicels, the valves smooth to occasionally slightly rough with minute hyaline ridges; replum narrowly oblong to sub-rectangular in outline, often twisted, the margin concave; style nearly absent to 0.8(1) mm. long, ca. 0.1-0.3 mm. wide, straight throughout, abruptly attached to the obtuse to truncate silique apex; stigma expanded to unexpanded in fruit; seeds regularly cordiform, 0.5-0.6 mm. long, ca. 30-70 per silique, the surface brown, finely colliculate; flowering and fruiting (April-May)June-October.

ILLUSTRATIONS: Gleason (1952, p. 241), as *R. obtusa*—the basal leaves and the single, separate short fruit to the right; Steyermark (1963, p. 759, pl. 185, no. 4); Stuckey (1966c, p. 415), photograph of portion of the type.

Rorippa truncata, like *R. tenerrima*, forms a massive, decumbent to prostrate, glabrous-stemmed, much-branched plant with deeply pinnatifid, angularly toothed basal and cauline leaves. The short, slender, ascending pedicels bear short cylindrical siliques constricted at the middle, with an obtuse to truncate apex, to which is abruptly attached a slender style sometimes with an expanded stigma. The replum has a concave margin and often becomes twisted when dry. *Rorippa truncata* can further be distinguished from its closest allies, the pinnate-leaved plants of Mexico and Central America, and from *R. curvipes*, in that the racemes are entirely lateral, developing first in the axils of the lower cauline leaves and progressing upward. Occasional plants have quite narrow (up to ca. 3 mm. wide) leaf lobes and extremely truncate fruits: Solano County, California (*Koch 1338*, FSU, MSC, WIS) and Dona Ana County, New Mexico (*Thurber 302*, GH, MO). This variation apparently has no taxonomic significance at the infraspecific level.

Rorippa truncata is closely related to *R. intermedia* in having similar leaves, silique size, and seed surface and size, but differs in growth behavior, more often smooth lower surface of the leaf, oldest siliques on lower axillary racemes, shorter pedicels, ca. 3 times as many seeds per silique, and flowering and fruiting usually in summer and fall instead of spring. The specimen of *R. intermedia* from Arizona (*Peebles & Harrison 1659*, NY) approaches *R. truncata* in petal length and silique shape with apex nearly truncate, thereby illustrating the morphological and geographical relationship between the species.

I grew *R. truncata* from my collection *1968* (San Bernardino County, California). Seeds were planted in August, September, and March and in all instances the plants began to flower within the third week after the seedlings emerged. The plants did not form a thick taproot. After about 2 months from the time of flowering some of the plants died, while others remained alive, flowered a second time, and then died. Flowering occurred irrespective of day length, as it did in *R. teres* in culture. The other species in culture, the winter annuals or perennials, required a longer growing period before flowering. They would not flower during short days of winter (November to March), and the rosettes usually continued to live after flowering and fruiting. These comparative observations suggest that *R. truncata*, a small, rather delicate plant with slender roots, is a short-lived annual. This species is usually collected from June to October in flower and fruit, further suggesting a summer or fall annual although in the Rio Grande valley, where the climate is milder compared to other areas of the species' range, fruiting collections have been made in spring. A few quite sturdy, tall plants with terminal racemes, similar to those of *R. intermedia*, were collected in spring by Suksdorf (*2464*, 27 May 1896, GH) in Washington, and by Eggert (1874, MO; 3 Jun 1877, GH, NY) and Engelmann (May 1845, MO; 26 Jun 1877, MO) in Missouri. These may be plants that persist over winter; by maturing the following spring, they behave more like winter annuals such as *R. curvipes*, *R. curvisiliqua*, and *R. palustris*.

There has been considerable confusion in distinguishing *R. truncata* and *R. teres* (*R. obtusa*) because of morphological similarities that have probably come about by parallelism in two separate evolutionary lines in section *Rorippa*. The two species are distinguished in Stuckey (1966c). *Rorippa truncata* also superficially resembles *R. tenerrima*. Both have essentially the same range although *R. tenerrima* grows in Nevada and Utah where *R. truncata* is absent; on the other hand, *R. truncata* seems to be more common in the Missouri River valley and in California northward from *R. tenerrima*. The two species are often found together, and many collections from the lower Missouri River valley, the Columbia River valley, and the Rio Grande contain mixtures of them. Some of our best naturalists—August Fendler, Charles Wright, Heinrich Eggert, George Engelmann, and William Suksdorf—made mixed collections. However, Engelmann, who never published his studies on *Rorippa* and was undoubtedly the most careful North American student of this genus, did notice the difference between these species, and he properly segregated some of his collections of *R. truncata* from *R. tenerrima*. The former he called "N. obtusum"; the latter, "N. obtusum umbrosum."

DISTRIBUTION: Map 11; 14; 20-P.

Rorippa truncata has a very odd distribution. Absent from the central Rocky Mountains, it occurs sparingly in the northern Rockies. Outward from here, it is nearly confined to the major river valleys—the Rio Grande, Columbia, Platte, and Missouri. It occurs in isolated situations in Arizona and California.

18. RORIPPA CURVIPES Greene, Pittonia 3: 97. 1896. [as "*Roripa*"]. ("Rather frequent in the mountains of southern Colorado at middle elevations," Lectotype: COLORADO: [Montrose Co.]: Near Cimaron, 30 Aug 1896, *E. L. Greene s.n.*, ND-G 5126! Isolectotype, ND-G 5125!)

Cardamine palustris ("Leysser" [Linnaeus]) O. Kuntze γ *jonesii* O. Kuntze, Rev. Gen. 1: 25. 1891. (Types: UTAH: [Salt Lake Co.]: City Creek Cañon, 27 Jul 1879, *Marcus E. Jones 1352*, GH! NY! Photo of the NY specimen at MICH! OS!).

Roripa [sic] *underwoodii* Rydberg, Bull. Torrey Club 29: 235. 1902. (Holotype: COLORADO: [Ouray Co.]: Red Mountain, s of Ouray, 3300 m, 11 Sep 1902, *L. M. Underwood 299a*, NY!)

Radicula curvipes (Greene) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Radicula underwoodii (Rydberg) Heller, Muhlenbergia 7: 124. 1912.

Radicula sinuata (Nuttall in Torrey et Gray) Greene var. *integra* Jepson, Man. Flowering Pl. Calif. 424. 1925. (Holotype: CALIFORNIA: Inyo Co.: Silver Cañon near Big Prospector Mdw, White Mts., 9700 ft, 30 Jul 1917, *W. L. Jepson 7354*, JEPS! Photo at OS!)

Glabrous summer or fall, usually winter annual, possibly a short-lived perennial; stems 1-5 dm. long, prostrate, decumbent, or erect, single or much branched from the base, sparingly to moderately hirsute on the lower portion; basal and lower cauline leaves short-petiolate to sessile, auriculate to non-auriculate, somewhat clasping to non-clasping, oblong, obovate, spatulate, or oblanceolate (2)4-8(12) cm. long, (0.3)0.6-1.5(3) cm. wide, the margins entire, crenate, irregularly serrate to repand, the apex obtuse to acute, or basal leaves occasionally pinnately divided to the midrib with middle lobes oblong to elliptic, the margins entire or slightly irregularly toothed and the terminal lobe acute to obtuse; lower surface of the leaves smooth and glabrous, upper surface smooth and glabrous to occasionally sparingly hirsute; racemes terminal and axillary, ca. 0.4-1.5 dm. long, forming during or somewhat after stem elongation, the siliques therefore nearly equal in age at corresponding points on the racemes or somewhat older on the lower portion of the terminal raceme; pedicels (1.6)2-5.1(8) mm. long, divergent, ascending, or strongly recurved, often in the same direction and giving the siliques the appearance of being borne unilaterally; sepals ovate to oblong, 0.8-1.7 mm. long, 0.4-1 mm. wide, flat to slightly saccate, caducous in fruit; petals oblong to narrowly or broadly spatulate, 0.5-2.4(2.8) mm. long, 0.2-1 mm. wide, equal to the sepals, or as much as ca. 0.5 mm. shorter than or ca. 1 mm. longer than them; siliques short- to elongate-cylindrical, straight to strongly curved upward and often inward toward the raceme axis, acute to obtuse below, not at all to strongly tapering upward, not at all or somewhat constricted in the center, (1.4)1.8-8.7 mm. long, 0.6-2.3 mm. wide, ca. 1.5-6(7) times as long as wide, ca. 0.5-2.2 times as long as the pedicels, the valves smooth; replum oblong to triangular in outline, seldom twisted, the margin straight to concave; style 0.2-1(1.3) mm. long, ca. 0.1-0.3 mm. wide in fruit, straight throughout, abruptly attached or gradually merging into the obtuse, acute, or pointed silique apex; stigma unexpanded in fruit; seeds regularly cordiform, ca. 0.5-0.7 mm. long, ca. 20-80 per silique, the surface brown, finely colliculate; flowering and fruiting May-September.

Rorippa curvipes is variable in growth habit, petal length, pedicel position and length, and silique shape and length. Although its leaves are variable in shape and lobing, the cauline leaves are never regularly pinnately divided or never regularly toothed, thus distinguishing it from *R. truncata* and the pinnate-leaved relatives in Mexico and Central America.

Rorippa curvipes appears adapted for survival as a short-lived perennial. In the greenhouse, when the plants became pot-bound, the roots formed new plants (basal rosettes) along the edge of the pot. The phenomenon of root propagation, common in *Sinuatae* and such European species as *R. sylvestris*, is apparently rare or uncommon in section *Rorippa*.

DISTRIBUTION: Map 12; 13; 14; 20-Q; 20-R.

Key to Varieties of Rorippa curvipes

1. Petals large, broadly spatulate, 1.2-2.3 mm. long, longer than the sepals; siliques usually acute at the apex; cauline leaves usually fewer than 10; plants decumbent to prostrate. . . . . 18b. var. *alpina*
1. Petals small, oblong to narrowly spatulate, 0.5-1.2(1.5) mm. long, shorter than or equal to the sepals; siliques pointed, acute to obtuse at the apex; cauline leaves usually more than 10; plants erect, decumbent, or prostrate (2)
    2. Siliques small, 1.4-5 mm. long, 1.5-2.5 times as long as wide, pointed, acute, or somewhat obtuse at the apex; pedicels usually recurved in plants from Arizona, Colorado, and New Mexico, usually ascending in those from Utah, Nevada, Oregon, Washington, Idaho, and Montana; petals 0.5-1 mm. long, mostly shorter than the sepals; plants decumbent to prostrate, occasionally erect. 18a. var. *curvipes*
    2. Siliques large, (3.5)5-8.1 mm. long, 2-3.5 times as long as wide, obtuse at the apex; pedicels divergent to ascending; petals 1-1.5 mm. long, mostly equal to the sepals; plants erect to somewhat decumbent. . . . . 18c. var. *integra*

18a. RORIPPA CURVIPES Greene var. CURVIPES

ILLUSTRATION: Fassett (1940, p. 232, fig. 14, 15), as *R. obtusa*—fruits excellent in being acute at the apex and on ascending pedicels; leaves somewhat atypical in being quite deeply divided.

As Greene (1896) pointed out in his original description, a distinguishing character of this variety is the strongly recurved pedicels that often bend back over the raceme axis to such an extent that the arrangement of pods on the raceme appears one-sided. The siliques are somewhat falcate and taper upward, the apex is strongly acute, and the very slender style has an unexpanded stigma in fruit. These features are common in plants from New Mexico and Colorado and sparingly northward into Utah, southern Idaho, and Montana. Through Wyoming and Utah, plants with acute siliques are common, but the pedicels are often ascending. Westward into Nevada and northward into Idaho and Montana are plants with fruits less tapering, somewhat to rather strongly obtuse at the apex, and on ascending pedicels. In these characters the variety is quite heterogeneous and geographical segregation is not well defined.

Rorippa curvipes and *R. truncata* are closely allied. They differ in longevity, manner of growth and raceme formation, leaf shape, silique shape, and replum characters. In *R. truncata* the ascending pedicels and obtuse to truncate fruit apex are distinctive; plants of var. *curvipes* have recurved pedicels and an acute silique apex. That the two species are related is shown by two specimens from southern Colorado: San Miguel Co., 15 Aug 1924, *E. B. and L. B. Payson* (GH, MO, MSC); Gunnison Co., *Stuckey 1666C* (MICH). The former has the growth pattern and somewhat pinnatifid leaves of *R. truncata*, but the pedicels are recurved and the siliques are strongly acute at the apex—features of var. *curvipes*. The specimen at MSC, however, agrees in all characters with var. *curvipes*. My collection resembles *R. truncata* in leaf morphology only. Several specimens from the northern portion of the range of var. *curvipes* have siliques similar to those of *R. truncata*. Most striking among plants with this fruit type are: ALBERTA: *Brinkman 3* (NY). MONTANA: Gallatin Co.: *Blankinship 59* (PH, US); Lewis & Clark Co.: *Kelsey yr. 1891* (NY); Treasure Co.: *Hayden s.n.* Aug 1859 (MO). IDAHO: Ada Co.: *Clark 299* (GH). These are placed in var. *curvipes* and are mapped (map 12).

The synonymy given before the species description applies to var. *curvipes*. Greene (1896) cited no specimens when he named this taxon, but of the material in his herbarium at Notre Dame, I found his collections ND-G 5125 and ND-G 5126 to be the only ones he labeled *R. curvipes* and collected before the publication date of *R. curvipes*. The lectotype comes from near Cimaron, Colorado, the type locality, and agrees perfectly with the original description.

Kuntze's (1891) var. *jonesii* under *Cardamine palustris* was based on specimens very similar to that of Greene's *R. curvipes*. The specimen at NY cannot be considered a holotype, since it was not part of Kuntze's original herbarium. It bears the stamp "Columbia College Herbarium New York." Kuntze apparently saw one of Jones' specimens in a private collection when he toured America in 1874.

Variety *curvipes* has often been misidentified as *R. obtusa*, *R. alpina*, *R. curvisiliqua*, or *R. palustris* and its synonyms. Most United States manuals not recognizing *R. curvipes* or *R. alpina* have included this taxon under *R. obtusa*.

DISTRIBUTION: Map 12; 14; 20-Q.

Variety *curvipes* occurs along irrigation ditches, streams, rivers, and lake shores at elevations between 7000–9000 (–11000) feet in the Central Rocky Mountains. Elsewhere it grows at lower elevations. There has apparently been natural migration eastward in the upper Missouri River valley, as a specimen from South Dakota was collected very early (1839). The collection from Michigan has the datum "common weed along edge of cultivated field." It undoubtedly is an introduction.

18b. RORIPPA CURVIPES Greene var. **alpina** (S. Watson) Stuckey, comb. nov.

Nasturtium obtusum Nuttall in Torrey et Gray var. (?) *alpinum* S. Watson, Bot. King's Exped. 15. 1871. (Holotype: UTAH: [Summit Co.]: Head of Bear River Cañon, Uintas, 10500 ft, Aug 1869, *Sereno Watson 60*, GH! Isotypes, NY! US! Photo of NY specimen at MICH! OS!)

Roripa [sic] *obtusa* (Nuttall in Torrey et Gray) Britton var. *alpina*

(S. Watson) Britton, Bull. Herb. Boiss. 3: 207. 1895.

Roripa [sic] *alpina* (S. Watson) Rydberg, Mem. N. Y. Bot. Gard. 1: 176. 1900.

Radicula alpina (S. Watson) Greene, Leafl. Bot. Obs. & Crit. 1: 114. 1905.

ILLUSTRATION: Hitchcock & Cronquist (1964, p. 540), as *R. obtusa* var. *alpina.*

Variety *alpina*, distinctive in having large petals longer than the sepals, is a short, compact plant with a stem which is mostly an inflorescence, that grows out laterally from the base of the plant. The stem usually has fewer than 10 leaves. The siliques may be quite long and pointed at the apex, or, especially in northeastern Utah, quite short and more obtuse. Long-fruited plants tend to have unlobed leaves with entire to irregularly crenate or serrate margins; short-fruited plants have leaves quite deeply, irregularly divided. On the few collections of plants of the latter morphology, mature fruits are often not available, and it is not yet possible to determine if silique size and leaf shape are correlated. The type specimen has large petals, over 2 mm. long, and unlobed entire leaves.

Western United States manuals have not recognized this taxon or have included it as a species or as a variety of *R. obtusa.* For reasons given below I cannot maintain it as a distinct species.

DISTRIBUTION: Map 13; 14.

Variety *alpina* represents a segregate confined to wet places at high altitudes in the central Rocky Mountains of the United States. In Colorado and Utah it is usually found above 10,000 feet, but in Wyoming and Montana it occurs down to about 7500 feet. Usually at lower elevations (8000–10000 feet in Utah and Colorado) is a transition zone where plants intermediate between var. *alpina* and var. *curvipes* occur. In these specimens, the petals are equal to or slightly longer than the sepals, mostly about 1.0-1.2 (1.5) mm. long, and the cauline leaf number is ca. 8-12. The localities of these intermediates are designated by "stars" in map 13. The intermediates are usually found at the outer limits of the range of var. *alpina.* From my collections in Gunnison County, Colorado (var. *curvipes, Stuckey 1666C, 1670, 1695*; var. *alpina, Stuckey 1666A, 1672, 1673*) I have grown both varieties in the greenhouse. The distinguishing characters of petal length and cauline leaf number were maintained when the plants were grown under similar conditions. However, in view of the many intermediates in an altitudinal transition zone between the two taxa, it is best to designate these taxa as varieties of the same species.

18c. RORIPPA CURVIPES Greene var. **integra** (Rydberg) Stuckey, comb. nov.

Roripa [sic] *integra* Rydberg, Bull. Torrey Club 29: 236. 1902. (Holotype: UTAH [probably Wasatch Co.]: Wahsatch [sic] Mts., 9000 ft, Aug 1869, *Sereno Watson 64,* NY! Isotypes, GH! US! Photo of GH specimen at MICH! OS!)

Radicula integra (Rydberg) Heller, Muhlenbergia 7: 124. 1912.

Rorippa obtusa (Nuttall in Torrey et Gray) Britton var. *integra* (Rydberg) Marie-Victorin, Contr. Inst. Bot. Univ. Montréal, 17: 9.t.6. 1930.

ILLUSTRATION: Marie-Victorin (1930, p. 10, fig. 6; 1947, p. 264) as *R. obtusa* var. *integra*—The latter is very poor!

Variety *integra* is an erect to somewhat decumbent plant usually single-stemmed or sparingly branched at the base. The leaves are obovate to broadly oblanceolate, unlobed, and entire, crenate, or somewhat serrate. The pedicels are divergent to ascending and bear long (usually over 5 mm.), slightly incurved siliques obtuse at the apex. This variety represents a morphological transition between *R. curvipes*, *R. curvisiliqua*, and *R. palustris*. It seems most closely allied to *R. curvipes*. There are specimens transitional to the other varieties of *R. curvipes*: Specimens from Bingham County, Idaho (*Davis 721*, GH) and from Beaver County, Utah (*Maguire 19837*, GH) have the strongly recurved pedicels of var. *curvipes*. A collection from Wyoming (*Payson 2744*, GH, MO, NY, PH, US) although good in fruit characters, consists of short, compact, decumbent plants with cauline leaves fewer than 10 and petals longer than the sepals. They are certainly close to var. *alpina*. The type specimen (*Watson 64*) has quite long petals (ca. 1.5-2.0 mm.) longer than the sepals, and young fruits acute at the apex. In these respects it approaches var. *alpina*. The upright growth, numerous oblanceolate leaves, and pedicel position are good characters for var. *integra*. Two Utah specimens (*Jones 1198*, NY, stamped Morong Herb.; *Hawkins*, 3 Aug 1919, WIS) are completely intermediate between all three varieties. The plants probably grew erect; the leaves are few and unlobed; the siliques, ca. 4-5 mm. long, acute at the apex, are on mostly ascending pedicels; and the petals—mostly fallen off—are 1-1.5 mm. long. The occurrence of all three varieties and a number of intermediates in northern Utah and adjacent areas makes this region the center of morphological diversity for *R. curvipes*.

A plant from Boise Basin, Idaho (*Mulford*, MO) is intermediate between var. *integra* and *R. curvisiliqua*. The short pedicels (ca. 2 mm.) and the style merging into the silique apex link this specimen to *R. curvisiliqua*. The silique shape and length and the leaf morphology are of var. *integra*.

The over-all aspect of var. *integra* is much like *R. palustris* var. *fernaldiana*. There is similarity in fruit shape, style attachment, and often in pedicel position. Variety *integra*, a delicate plant, has an unexpanded stigma in fruit, upper leaf surface usually glabrous, and leaves undivided and more rounded at the apex. In contrast, var. *fernaldiana*, a sturdy plant, has an expanded stigma in fruit, hirsute upper leaf surface, and often quite lacinate-divided leaves acute at the apex.

Marie-Victorin (1930) misidentified specimens of *R. palustris* when he made the combination *R. obtusa* var. *integra* and applied that name to plants from the St. Lawrence River. His illustration, however, is a fair representation of var. *integra*.

DISTRIBUTION: Map 13; 14; 20-R.

Variety *integra* is distributed northwest of var. *alpina* and of the greatest concentration of var. *curvipes* (Utah and southeastward). Variety *curvipes* does occur sparingly, however, throughout most of the range of var. *integra*. The latter would be expected to appear most frequently in northern and western Utah, northern Nevada, and northward through Idaho and western Montana. Its occurrence westward from Idaho is along the Columbia River —the result of downriver migration from northern Idaho and northeastern Washington.

Not only is var. *integra* morphologically intermediate between *R. curvisiliqua*, *R. palustris*, and the other varieties of *R. curvipes*, but it also lies between or partially within their ranges. That it is not an occasional hybrid between any of these taxa is supported by specimens from northwestern Utah and northern Nevada—areas where only one of these allies is known.

19. RORIPPA SPHAEROCARPA (Gray) Britton, Mem. Torrey Club 5: 170. 1894. [as "*Roripa*"].

Nasturtium sphaerocarpum Gray, Mem. Am. Acad. n.s. 4: 6. 1849; Pl. Fendl. 6. 1849. ("Low places along Santa Fe Creek." Holotype: NEW MEXICO: [Santa Fe Co.]: [Santa Fe], 1847, *A. Fendler 31* [Gray's no. 21], GH! Isotypes, MO! PH! Photo of MO specimen at MICH! OS!)

Cardamine globosa (Turczaninow) O. Kuntze 3. *sphaerocarpa* (A. Gray) O. Kuntze, Rev. Gen. 1: 25. 1891.

Nasturtium obtusum Nuttall in Torrey et Gray var. *sphaerocarpum* (Gray) Watson ex Allen, Check-list Gray's Man. 123. 1893.

Radicula sphaerocarpa (Gray) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Radicula obtusa (Nuttall in Torrey et Gray) Greene var. *sphaerocarpa* (Gray) Robinson, Rhodora 10: 32. 1908.

R. [i.e. *Roripa*] *obtusa* (Nuttall in Torrey et Gray) Britton var. *sphaerocarpa* (Gray) "Robinson" Britton et Brown, Ill. Fl. 2nd. ed. 2: 161. 1913, pro syn. [Combination made by error for *Radicula obtusa* var. *sphaerocarpa*, but invalid because published in synonymy.]

Rorippa obtusa (Nuttall in Torrey et Gray) Britton var. *sphaerocarpa* (Gray) Cory, Rhodora 38: 406. 1936.

Glabrous summer, fall, or usually winter annual; stems 1-4 dm. long, decumbent to erect, single or much branched from the base, sparingly hirsute on the lower portion; basal and cauline leaves short-petiolate to sessile, auriculate to non-auriculate and non-clasping, oblong to oblanceolate, 4-10 cm. long, 0.7-1.3(3) cm. wide with the margins entire, crenate, irregularly serrate to repand and the apex obtuse to acute, or pinnately divided to the midrib with middle lobes oblong to elliptic, 3-7 mm. long, 2-5 mm. wide, their margins toothed to somewhat entire and the terminal lobe as wide or wider than the laterals, acute to obtuse at the apex; racemes terminal and axillary, ca. 0.5-1 dm. long, forming simultaneously during stem elongation, the siliques therefore nearly equal in age at corresponding points on the racemes, or racemes lateral, developing during stem elongation in the axils of the lower leaves and progressing upward, without the formation of a true terminal raceme, the oldest siliques therefore on the lower axillary racemes; pedicels (1.5)2-4.2 mm. long, ascending or strongly recurved, often in the same direction and giving the siliques the appearance of being borne unilaterally; sepals ovate to oblong, 0.8-1.3 mm. wide, flat to slightly saccate, caducous in fruit; petals oblong to narrowly spatulate, 0.6-1.2 mm. long, 0.2-0.5 mm. wide, as much as 0.5 mm. shorter than the sepals; siliques globose, (0.8)1-2.5 mm. long, 1-2.5 mm. wide, ca. 1-1.3 times as long as wide, ca. 0.5-1 times as long as the pedicels, the valves smooth; replum circular in outline; style 0.1-1 mm. long, ca. 0.1-0.2 mm. wide in fruit, straight throughout, abruptly attached to the rounded silique apex; stigma unexpanded in fruit; seeds regularly cordiform, ca. 0.5-0.7 mm. long, ca. 10-20 per silique, the surface brown, finely colliculate; flowering and fruiting May-August(September).

ILLUSTRATION: Britton & Brown (1897, p. 125, fig. 1716; 1913, p. 161, fig. 2029)

The globose fruit is the only significant character separating *R. sphaerocarpa* from *R. curvipes* and *R. truncata*, but it is a perfectly distinct one. That this species is most closely related to *R. curvipes* var. *curvipes* is shown by specimens collected in Utah by Jones (*5445b*, NY, US) and Beck and Tanner (*8203*, US). I identify both as *R. curvipes* var. *curvipes*, but some siliques are nearly globose.

In leaf and growth characteristics, *R. sphaerocarpa* is somewhat heterogeneous. Specimens from Colorado and New Mexico resemble *R. curvipes* in raceme formation, strongly recurved pedicels, and cauline leaves mostly unlobed or irregularly divided (not pinnatifid); specimens from Arizona and California approach *R. truncata* in that the oldest siliques are on the lower lateral racemes, the pedicels are very short and ascending, and the cauline leaves are pinnatifid and toothed.

Plants of *R. sphaerocarpa* grown in the greenhouse from seed of my collection *1732A*, obtained in Boulder County, Colorado, had globose siliques on strongly recurved pedicels, matching plants collected in the field. Some offspring from one greenhouse plant produced lateral racemes beginning in the lower leaf axils and progressing upward without forming a true terminal raceme; other offspring produced both a terminal and lateral racemes simultaneously. The former condition is found in plants from Arizona and California; the latter, in plants from New Mexico and Colorado. Greenhouse observations confirm that both types of raceme formation occur in the species.

Britton and Brown (1913), Winter (1936), and Hitchcock and Cronquist (1964) suggested these globose-fruited plants might be a minor variant or race of what they called *R. obtusa*. Because plants with long pods (*R. cur-*

vipes) and plants with globose pods (*R. sphaerocarpa*) retain their pod shape under similar conditions in the greenhouse, I maintain the two as separate taxa.

Rorippa sphaerocarpa has not adequately been understood. The Kansas report by Holzinger (1892) is based on a specimen of *R. curvipes* var. *curvipes*. Fassett (1940), recording the species as "mostly in the Mississippi Valley, n. to Wis.," confused it with *R. truncata* and possibly *R. palustris*. Gleason (1952) thought plants of *R. truncata* were *R. sphaerocarpa* (Stuckey, 1966c). Globose-fruited specimens of *R. palustris* from Idaho, often labeled *R. sphaerocarpa*, were the basis of Greene's idea of *R. sphaerocarpa*. Howell's (1897) description of *R. sphaerocarpa* characterizes the globose-fruited, hirsute members of *R. palustris*. *Rorippa sphaerocarpa* does not occur in the Mississippi River valley or the Pacific Northwest. Jones and Fuller (1955) correctly stated that it does not occur east of the Mississippi.

DISTRIBUTION: Map 13; 14.

Rorippa sphaerocarpa occurs locally along streams, ditches, and lake shores in mountains of southwestern United States at elevations below 9000 feet. The exact limits of its range are still somewhat in doubt. The northern limit as given in map 13 is probably accurate, as this area has been more collected than many others on the edge of its range. The eastern edge of the Rocky Mountains is the natural "cut-off" on the east. This is the limit of 16 or more inches of rainfall per year (map 14).

Summary of the Rorippa curvipes complex. The *R. curvipes* complex consists of *R. curvipes* and its varieties, *R. truncata*, and *R. sphaerocarpa*. Plants of these taxa, often misidentified as *R. obtusa*, form the incorrect concept of *R. obtusa* presented in most current manuals. The diffusely branched, glabrous, prostrate to decumbent plants usually with short petals (less than 1.2 mm. except in var. *alpina*), and the relatively small, readily dehiscent siliques with a slender abruptly attached style are features uniting this group.

In the discussion under each species, I pointed out specimens intermediate between these taxa. These intermediates come from northern Utah or adjacent states—nearly the center of range of members of this complex. Radiating from this center is a short, slender, somewhat falcate-fruited plant with numerous cauline leaves (*R. curvipes* var. *curvipes*). To the south the pedicels are strongly recurved and the siliques are shorter and sharply acute to pointed at the apex. North and west, the pedicels are ascending and the fruit apex is more obtuse. Because of intergradation throughout the population, assigning these variants to separate taxa is not justified. From this center and northeast at high elevations, plants with long petals and few cauline leaves are found (var. *alpina*); and radiating northwest is a more robust plant, mostly with large undivided leaves and long obtuse fruits (var. *integra*). These two intergrade with *R. curvipes* and are therefore treated as varieties of it. The globose-fruited *R. sphaerocarpa* of southwestern United States is divergent in fruit shape from other members of the complex and is therefore accorded species rank.

Rorippa truncata shows much morphological deviation from other taxa of this complex. It found its way into major drainage avenues of the United States, far down the Rio Grande, Columbia, Platte, and Missouri rivers, where it successfully exists without the immediate influence of other members of the complex. If it ever existed in the mountains, it has died out in the central Rockies but has held on in northern Idaho and western Montana. Elsewhere it is nearly confined to outlying river valleys, except for isolated occurrences in Arizona and California. The plants of *R. curvipes* var. *curvipes* having a few characters of *R. truncata* may represent the few surviving members whose ancestors were probably prototypes of *R. truncata.*

Map 14 shows the entire *R. curvipes* complex in western United States in relation to 16-inch annual rainfall isohyet. As in *R. curvisiliqua* and *R. microtitis*, the plants come mainly from areas of more than 16 inches of rainfall.

20. RORIPPA PALUSTRIS (Linnaeus) Besser, Enum. Pl. Volh. 27. 1822. [as "Roripa"].

[In European literature, there are several taxonomic synonyms for this species, but they are not taken into consideration here because the types have not been seen. For example, see A. P. DeCandolle (Syst. Nat. 2: 191. 1821), Wannenmacher (Hegi Ill. Fl. von Mittel-Europa. ed. 2. 4(2): 172. 1960), and Jonsell (Symb. Bot. Upsal. 19: 157. 1968).]

Sisymbrium amphibium α *palustre* Linnaeus, Sp. Pl. 657, 1753. ("Habitat in Europae septentrionalioris aquosis." Lectotype: Suecia (?), "Lapponica," *C. Linnaeus s.n.*, Institut de France, *fide* Jonsell, 1968, p. 157).

Sisymbrium palustre (Linnaeus) Pollich, Hist. Pl. Palat. 2: 230. 1777. Non Garsault 1767.

Sisymbrium palustre (Linnaeus) Leysser, Fl. Hal. ed. 2. no. 679. p. 166. 1783.

Myagrum palustre [(Linnaeus)] Lamarck, Encycl. Meth. Bot. 1, pt. 2. 572. 1785.

Sisymbrium terrestre Withering, Bot. Arr. Brit. Pl. ed. 2. 2: 692. 1787. [Based on *Sisymbrium amphibium* α *palustre* Linnaeus]

Caroli-Gmelina palustris (Linnaeus) Gaertner, Meyer, & Scherbius, Fl. Wett. 2: 470. 1800.

Radicula palustris ("Pollich" [Linnaeus]) Moench, Meth. 263. 1794. [Since Moench cites Pollich (an illegitimate homonym), this name would be treated as new according to Art. 72, if we did not assume it was actually based on the Linnaean epithet.]

Brachyolobos palustris Clairville, Man. Herb. 218. 1811. [Clairville does not cite any author for his epithet. Presumably it is based on Linnaeus.]

Nasturtium terrestre (Withering) R. Brown in Aiton, Hort. Kew. ed. 2.

4: 110. 1812.

Nasturtium palustre ("Leysser" [Linnaeus]) A. P. DeCandolle, Syst. Nat. 2: 191. 1821. [Since DeCandolle cites Leysser (an illegitimate homonym), this name would be treated as new according to Art. 72, if we did not assume it was actually based on the Linnaean epithet.]

Roripa [sic] *terrestris* (Withering) Fuss, Fl. Transsilv. Exc. 47. 1866.

Cardamine palustris ("Leysser" [Linnaeus]) O. Kuntze, Rev. Gen. 1: 24. 1891.

Roripa [sic] *terrestris* ("R. Brown in Aiton" [Withering]) A. Nelson, Bot. Gaz. 52: 264. 1911.

Radicula terrestris ("R. Brown in Aiton" [Withering]) Wooton et Standley, Contr. U. S. Natl. Herb. 19: 284. 1915.

Summer, fall, or winter annual, occasionally biennial or short-lived perennial stems (1)3-10(14) dm. long, erect, rarely decumbent or prostrate, single or much branched from the base, glabrous throughout or sparingly to densely hirsute below and becoming sparingly hirsute to glabrous above; basal and lower cauline leaves short-petiolate to sessile, slightly auriculate and clasping or non-auriculate and non-clasping, oblong to oblanceolate, (4)6-20(30) cm. long, 1-5(8) cm. wide, both surfaces glabrous or sparingly to densely hirsute, the margins irregularly serrate, incised, deeply cleft, repand, or variously pinnate-divided, the apex narrowly to broadly acute or somewhat attenuate; racemes terminal and axillary, ca. 0.3-2 dm. long, forming after stem elongation, the oldest siliques therefore on the lower portion of the terminal raceme; pedicels 1.9-13.8 mm. long, glabrous to sparingly hirsute, slightly to strongly recurved, divergent, or ascending; sepals ovate to oblong, 1.2-2.5 mm. long, 0.4-1.4 mm. wide, flat to somewhat saccate, caducous in fruit; petals oblong to broadly spatulate, 0.8-3.5 mm. long, 0.5-2.2 mm. wide, shorter than or equal to the sepals or occasionally longer than the sepals; siliques globose, subglobose, oblong, ellipsoid, or short- to elongate-cylindrical, straight to somewhat curved upward and inward toward the raceme axis, acute to obtuse below, not at all to slightly tapering, or becoming clavate toward the apex, 2.2-14 mm. long, 0.8-3.7 mm. wide, ca. 1-8 times as long as wide, ca. 0.2-2 times as long as the pedicels, the valves smooth, glabrous; replum narrowly elongate-oblong, elliptic, or circular in outline, sometimes twisted, the margin concave, straight, or strongly convex and glabrous; style 0.2-1.2 mm. long, ca. 1-3(5) mm. wide in fruit, straight throughout, mostly abruptly attached to the truncate, obtuse, or acute silique apex; stigma expanded or unexpanded in fruit; seeds regularly cordiform, 0.5-0.9 mm. long, ca. 20-80 per silique, the surface brown to reddish-brown, colliculate; flowering and fruiting May-October.

Rorippa palustris is extremely variable, especially in leaf lobing and texture, fruit size and shape, pedicel length and position, and trichome distribution. It is distinctive in that it is the only native North American *Rorippa* that combines bivalved siliques, erect growth, and terminal and lateral racemes formed after the stem has elongated. Two possible exceptions to the growth feature are found in *R. pinnata* and *R. intermedia* of Mexico and Central America. In this character *R. palustris* does merge, via var. *fernaldiana*, with its closest relative, *R. curvipes* var. *integra*, in the Rocky Mountains of western Montana. Variety *integra* grows erect or somewhat decumbent and forms its racemes after the stem has partially elongated. It is a somewhat delicate plant, whereas *R. palustris* is a stout, thick-stemmed, sturdy, and often very tall plant with coarse, heavy foliage and is taller than any other native North American species.

Because *R. palustris* is extremely variable, recent North American accounts of it have differed. Some recognize one species, under the name *R. palustris* or *R. islandica*, with two or more varieties (e.g. Marie-Victorin, 1930; Deam, 1940; Fernald, 1940, 1950; Gleason, 1952; Gleason & Cronquist, 1963; Hitchcock & Cronquist, 1964; Steyermark, 1963); others recognize two, a glabrous one, *R. palustris* or *R. islandica*, and a hirsute one, *R. hispida* (e.g., Fernald, 1928; Abrams, 1944; Harrington, 1954; Hultén, 1945; Jones & Fuller, 1955; Jones, 1963; Kearney & Peebles, 1951; Mason, 1957). I regard *R. palustris* as one highly polymorphic species as did Butters and Abbe (1940) and have sorted the complex into several morphological and geographical segregates. By using both the subspecific and varietal ranks, I attempt to portray levels of morphological complexity and geographical segregation.

Jonsell (1968) presented the taxonomic distinctions and elucidated the nomenclature for *R. palustris* and *R. islandica*, concluding that the two are separate species. Table 1 gives the major characteristics of these taxa in northwestern Europe as summarized from his work.

Rorippa islandica occurs in coastal southern Greenland, Iceland, northern Norway, and the British Isles; in the Alps and Pyrenees; and along some large Russian and Siberian rivers. Jonsell (1968) gives an illustration of the plant (fig. 6, p. 55) and a map of its distribution (fig. 7, p. 56).

Rorippa islandica is not known from the North American continent. A specimen from Anticosti Island (*Marie-Victorin & Rolland-Germain 27265*, GH, PH!, WIS!; fig. 8, p. 14 in Marie-Victorin, 1930; fig. 2, p. 229 in Fassett, 1940) is very similar to European *R. islandica*. Jonsell (1968) noted that its habit, flower size, and foliage suggested European *R. islandica* but that the leaflets were more dissected and the petioles possessed distinct basal auricles. He concluded it was separate from *R. islandica*. The Anticosti specimen is a delicate, decumbent plant with the oldest siliques on lower axillary racemes; a terminal raceme is absent; and the stigma is unexpanded in fruit. In these characters it is distinct from North American *R. palustris* but closely resembles *R. truncata*, differing from it in slightly thicker siliques on somewhat longer pedicels. This plant's identity is doubtful but it may be a variant of *R. islandica* from Europe or of *R. truncata* and its relatives.

As Jonsell (1968) explained, the basionym of *R. islandica* is *Sisymbrium islandicum* Oeder (Flora Danica 3: pl. no. 409. 1768). He stated that this

TABLE 1. CHARACTERISTICS SEPARATING RORIPPA PALUSTRIS AND RORIPPA ISLANDICA.

CHARACTER	*R. palustris*	*R. islandica*
Chromosomes	tetraploid ($2n=32$)	diploid ($2n=16$)
Sepal length in mm.	long (ca. 1.4-2.4)	short (ca. 1.2-1.7)
Petal length in mm.	long (ca. 1.5-2.6)	short (ca. 1-1.7)
Pollen grain, equatorial diameter in microns	ca. 23-27	ca. 18-23
Silique length in relation to pedicel length	not longer than twice the length of the pedicels	about twice the length of the pedicels
Base of silique	widens only gradually from the point of attachment; valves do not reach fully down to the pedicel, therefore separated by a sterile portion of the silique usually ca. 0.2-0.3 (0.5) mm. long	widens more abruptly from the point of attachment; valves reach down to the pedicel, therefore separated by a sterile portion of the silique not longer than ca. 0.1 mm.
Valve texture	thick and firm	thin and transparent
Petioles of middle cauline leaves	distinctly winged and with auricles, making the leaves appear sessile	inconspicuously winged and without auricles, making the leaves appear stalked
Stems	erect	prostrate

illustration shows many features distinguishing *R. islandica* from *R. palustris*; he did not elaborate on these. The plant shown is from Iceland where Oeder obtained seeds collected by Koenig during 1764-65. In Copenhagen, plants were grown from these seeds, and Oeder's plate apparently was prepared from one of these plants. Jonsell found no herbarium specimens connected with Oeder's plate.

References to *R. islandica* in my papers (Stuckey, 1966a, 1966b, 1966c) should be referred to *R. palustris*.

Key to Subspecies of Rorippa palustris

1. Leaves hirsute on the lower surface; stems hirsute usually up to the terminal raceme. . . . . 20. iv. subsp. *hispida*
1. Leaves glabrous on the lower surface; stems glabrous or sparingly hirsute below (2)
    2. Plants short, mostly 1-4 dm., often with a purplish cast to the stem and foliage; stems slender, mostly under 3 mm. in diameter; leaves thin-textured. . . . . 20. i. subsp. *palustris*

2. Plants tall, mostly over 4 dm., often with a reddish cast to the stem and foliage; stems thick, mostly over 3 mm. in diameter; leaves thick-textured (3)

3. Siliques mostly longer than 7 mm.; stigma unexpanded in fruit. . . . . 20. ii. subsp. *occidentalis*

3. Siliques mostly shorter than 7 mm.; stigma expanded or unexpanded in fruit. . . . . 20. iii. subsp. *glabra*

20i. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. PALUSTRIS

Plants delicate, mostly 1-4 dm. tall, entirely glabrous except occasionally hirsute on the upper surface of the leaves; stems slender, mostly under 3 mm. in diameter; petals 1.3-2.5 mm. long, shorter than the sepals; pedicels 4.8-9 mm. long, mostly divergent; siliques ellipsoid or elongate-cylindrical, 4-8.7 mm. long, 1-2.7 mm. wide; stigma strongly expanded in fruit.

Key to Varieties of Subspecies palustris

1. Apex of basal leaves obtuse with angle of ca. (60°)80°-120°; apex of middle cauline leaves with angle of ca. (40°)60°-120°; siliques acute or pointed at the apex. . . . . 20a. var. *palustris*

1. Apex of basal leaves acute with angle of ca. 40°-80°(100°); apex of middle cauline leaves with angle of ca. 30°-60°(70°); siliques obtuse at the apex. 20b. var. *williamsii*

20a. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. PALUSTRIS var. PALUSTRIS

ILLUSTRATIONS: Butcher (1961, p. 336, no. 223), portion of plant, flower, silique, seed, as *R. islandica*; Clapham, Tutin, and Warburg (1962, p. 173, fig. 23, B), silique, as *R. islandica*; Jonsell (1968, plate V, fig. B), photograph of siliques; Jonsell (1968, plate V, fig. E, F), photographs of entire plants.

The typical variety is a short, slender-stemmed thin-leaved plant with ellipsoid or elongate-cylindrical siliques somewhat pointed near the apex, and a style with a strongly expanded stigma.

Synonymy for the nomenclaturally typical subspecies and variety is given before the species description.

Fernald (1928) was doubtful whether var. *palustris* [his *R. islandica*] is native in eastern North America. On the basis of the specimens he cited (except *Marie-Victorin* and *Rolland-German 27265*, GH, PH, WIS), we agree on the concept of this taxon. Plants from the vicinity of New York, the Delaware River valley, and the Washington, D.C., area, usually from waste places, probably are introductions from Europe. Plants of upper and central New York and New England coming primarily from river banks and lake shores may be native populations extending eastward from those of the western part of the continent. Specimens from Alberta and Saskatchewan have the upper leaf surface sparingly hirsute, like var. *fernaldiana*—one aspect of introgression between these varieties.

The typical variety of *R. palustris* occurs throughout Europe except in the Mediterranean region (Jonsell, 1968). It is absent from Iceland, the type locality of *R. islandica*.

DISTRIBUTION: NORTHERN NORTH AMERICA: Map 15. NORTHWESTERN EUROPE: Hultén (1950, p. 237, map 925), as *R. islandica*; Jonsell (1968, p. 67, fig. 8).

20b. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. PALUSTRIS var. WILLIAMSII (Britton) Hultén, Fl. Alaska & Yukon 5: (Lunds Univ. Arssk. II. Sect. 2. 41:) 828. 1945.

Rorippa williamsii Britton, Bull. N. Y. Bot. Gard. 2: 171. 1901. (Holotype: CANADA: YUKON: Near mouth of Bonanza Creek, 18 Jun 1899, *R. S. Williams s.n.*, NY! Photo at MICH! OS!)

Radicula williamsii (Britton) Heller, Muhlenbergia 7: 124. 1912.

Nasturtium williamsii (Britton) Standley, Field Mus. Publ. Bot. [Fieldiana Bot.] 8: 312. 1931.

The range of var. *williamsii* extends from unglaciated central Alaska onto glaciated northern Alaska, across the Yukon and Mackenzie to Churchill, Manitoba. The variety is absent from glaciated southeastern Alaska. A few specimens at US from eastern Asia are similar to this variety.

DISTRIBUTION: Map 15.

20. ii. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. OCCIDENTALIS (S. Watson in Gray) Abrams, Ill. Fl. Pacific States 2: 278. 1944.

Nasturtium terrestre [(Withering)] R. Brown in Aiton var. *occidentale* S. Watson in Gray, Syn. Fl. 1: 148. 1895. ("Shumagin Islands, Alaska, *Dall*, to Brit. Columbia, *Lyall, Macoun*, and the Lower Columbia Valley, *Hall, Suksdorf, Howell*." Lectotype: ALASKA: Popoff Strait, Shumagin I[slan]ds, 15 Oct 1873, *W. T. Dall s.n.*, GH!)

Roripa [sic] *pacifica* Howell, Fl. N. W. Am. 1: 40. 1897. [Based on *Nasturtium terrestre* [(Withering)] R. Brown in Aiton var. *occidentale* S. Watson in Gray]

Radicula pacifica (Howell) Greene, Leafl. Bot. Obs. & Crit. 1: 114. 1905.

Rorippa palustris (Linnaeus) Besser var. *pacifica* (Howell) G. N. Jones, Univ. Wash. Publ. Biol. 5: 161. 1936.

Rorippa islandica (Oeder ex Murray) Borbás var. *occidentalis* (S. Watson in Gray) Butters et Abbe, Rhodora 42: 27. 1940.

Plants stout, mostly 4-10(14) dm. tall, entirely glabrous; stems thick, mostly over 3 mm. in diameter; petals 1.2-3.5 mm. long, equal to or slightly longer than the sepals; pedicels (4.5)6-11(13.8) mm. long; siliques elongate-cylindrical, (6.2)7-14 mm. long, 1.6-3.7 mm. wide; stigma unexpanded in fruit.

Key to Varieties of Subspecies occidentalis

1. Siliques straight, not at all or slightly tapering upward with apex acute to obtuse; pedicels ascending or occasionally divergent. . . . . 20c. var. *occidentalis*
1. Siliques curved upward, becoming clavate upward with apex obtuse to truncate; pedicels divergent or somewhat recurved. . 20d. var. *clavata*

20c. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. OCCIDENTALIS (S. Watson in A. Gray) Abrams var. OCCIDENTALIS

ILLUSTRATION: Anderson (1959, p. 275, fig. 536), silique, seed, leaf—poor!

Variety *occidentalis* is known from two regions of western North America. The first extends from northern Idaho (one of the centers of morphological diversity) to the California mountains, the lower Colorado River valley, the Rio Grande valley, and Mexico City. Some specimens from the California coast are somewhat transitional toward var. *clavata* in the slightly longer, more upcurved siliques tending to be more obtuse at the apex. The pedicels are more divergent—often at right angles to the axis.

The second region is coastal Alaska where plants are shorter (up to ca. 4 dm. in contrast to those of the first region, which reach over 7 dm.) and the siliques are mostly obtuse at the apex.

DISTRIBUTION: Map 15.

20d. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. OCCIDENTALIS (S. Watson in Gray) Abrams var. **clavata** (Rydberg) Stuckey, comb. nov.

Roripa [sic] *clavata* Rydberg, Bull. Torrey Club 29: 235. 1902. (Holotype: WASHINGTON: Chelis Co.: [Gray's Harbor Co.]: Hoquiam, 29 Jun 1897, *F. H. Lamb 1221,* NY! Isotypes, MO! PH! US! Photo of PH specimen at MICH! OS!)

Radicula clavata (Rydberg) Macoun, Ottawa Nat. 20: 142. 1906.

Nasturtium clavatum (Rydberg) Standley, Field Mus. Pub. Bot. [Fieldiana Bot.] 8: 312. 1931.

The curved siliques gradually widening apically are distinctive. The ultimate in silique length (ca. 14 mm.) is reached in var. *clavata*. This variety grows in coastal southeastern Alaska south to western Washington, and along the lower Columbia River.

I grew plants of var. *occidentalis* from California (*Piehl 631136*, MICH) and var. *clavata* from Oregon (*Stuckey 1926A*) under similar conditions in the greenhouse; the distinguishing characters were retained.

20. iii. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. **glabra** (O. E. Schulz) Stuckey, comb. nov.

Nasturtium palustre ("Leysser" [Linnaeus]) A. P. DeCandolle subsp. *hispidum* (Desvaux) "Fischer et Meyer" [O. E. Schulz] var. *glabra* O. E. Schulz, Symb. Antill. 3. 516. 1903.("Hab[itat] in Cuba: Wright n. 1862." Holotype: CUBA: [ORIENTE]: [Without locality], 1860-1864, *C. Wright 1862*, presumably at B. Isotypes, GH! MO! Photo of MO specimen at MICH! OS!)

Radicula glabra (O. E. Schultz [sic] Britton, Torreya 6: 30. 1906.

Roripa [sic] *terristris* [sic] ("R. Brown in Aiton" [Withering]) A. Nelson var. *globosa* A. Nelson, Bot. Gaz. 52: 264. 1911. ("Macbride 275 is typical . . .; also by Aven Nelson, Head of Wood's Creek, Albany Co., Wyoming, August 1910." Lectotype: IDAHO: Canyon Co.: Swampy land, Falk's Store, 22 Jun 1910, *J. Francis McBride 275*, US! Photo at MICH! OS! Isolectotype, NY! [Since I have not seen the specimen that A. Nelson apparently had (presumably at RM), I am selecting the specimen at US as the lectotype. A duplicate at MO! is hirsute on the lower surface of the leaves and belongs to *Rorippa palustris* subsp. *hispida* var. *hispida*.])

Plants stout, mostly 4-10 dm. tall; stems thick, mostly over 3 mm. in diameter, glabrous to sparingly hirsute below, glabrous above; leaves glabrous on the lower surface, sparingly hirsute to glabrous on the upper surface; petals 0.8-2 mm. long, equal to or shorter than the sepals; pedicels (1.9)2.7-5.5(7.6) mm. long; siliques globose, subglobose, oblong, short- to elongate-cylindrical, (0.8)1.2-3.4 mm. wide.

Key to Varieties of Subspecies glabra

1. Stigma expanded in fruit; replum margin concave, becoming twisted with age and upon drying (except in var. *dictyota*) (2)
1. Stigma unexpanded in fruit; replum margin straight or convex, remaining flat with age and upon drying (3)
    2. Siliques mostly elongate-cylindrical, straight throughout, (3.8) 4.7-7 mm. long; basal and lower cauline leaves sinuate-lobed or unlobed with irregularly serrate margins; upper cauline leaves glabrous on the upper surface; pedicels divergent to ascending. . . . . 20f. var. *dictyota*
    2. Siliques mostly short-cylindrical, constricted at the center, 2.5-4.3(5.6) mm. long; basal and lower cauline leaves lacininate or pinnate-divided; upper cauline leaves hirsute on the upper surface; pedicels divergent to slightly recurved. . . . . . . 20g. var. *fernaldiana*
3. Siliques globose to subglobose, 2.2-4 mm. long; cauline leaves usually sparingly hirsute on the upper surface; pedicels divergent to ascending. . . . . 20e. var. *glabra*
3. Siliques oblong or elongate-cylindrical, 4.7-7 mm. long; cauline leaves glabrous or sparingly hirsute only on the midrib on the upper surface; pedicels divergent to strongly recurved (4)
    4. Pedicels divergent; siliques as wide at the apex as at the base. . . . . 20h. var. *glabrata*
    4. Pedicels strongly recurved; siliques usually wider at the apex than at the base. . . . . 20i. var. *cernua*

20e. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. GLABRA (O. E. Schulz) Stuckey var. GLABRA

ILLUSTRATION: Fernald (1940, opposite p. 261, pl. 605, fig. 3), photograph of silique.

Plants of var. *glabra* are similar in having globose to subglobose siliques, an unexpanded stigma, mostly divergent pedicels, and the upper leaf surface glabrous to sparingly hirsute, but genetically and evolutionarily they may have different origins. Specimens from southern Idaho, Utah, and northern New Mexico are similar (except for trichome distribution) to var. *hispida*, the only other *R. palustris* segregate growing there. These glabrous plants and var. *hispida* apparently grow together west of the Continental Divide. East of the Divide (except in Montana) such glabrous plants are not known. Variety *glabra* may be isolated from var. *hispida* in the Glacier National Park area of Montana where the latter appears to be rare or absent. A few plants from western Montana and northern Idaho look like var. *fernaldiana* but have the short fruit and unexpanded stigma of var. *glabra*. All Cuban specimens of *R. palustris* belong to var. *glabra;* the occurrence and disjunction there are difficult to explain; It is unlikely that plants would have been introduced from the central Rocky Mountains. Wright's collection of ca. 1860 is an old one; certainly at that period, when the Rocky Mountains were little explored, there would have been slight chance of an inland United States plant being brought to Cuba.

DISTRIBUTION: Map 16; 20-S

20f. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. GLABRA (O. E. Schulz) Stuckey var. **dictyota** (Greene) Stuckey, comb. nov.

Nasturtium dictyotum Greene, Fl. Franciscana 2: 268. 1891. (Holotype: CALIFORNIA: [Probably Solano Co.]: Grand Island, Lower Sacramento River, 17 Sep 1891, *W. Jepson s.n.*, ND-G 5136!)

Roripa [sic] *dictyota* (Greene) Greene, Man. Bot. San Francisco Bay 20. 1894.

Radicula dictyota (Greene) Greene, Leafl. Bot. Obs. & Crit. 1: 113. 1905.

Variety *dictyota* is distinctive in being glabrous and in having rather long fruits, ascending pedicels, and a much-branched often extremely hard, stout, and sturdy stem. It is unique in having leaves either unlobed (though irregularly serrate) or regularly sinuate-lobed. I found it to be common in the lower Columbia River valley. Seeds from unlobed-leaved plants produced plants with unlobed leaves, and those from lobed-leaved plants produced plants with lobed leaves. No other morphological features to separate plants of the leaf types could be found. Furthermore, they have the same range. The plants are morphologically diverse in northern Idaho and western Montana, as shown by the few specimens from Idaho and some of the plants of my mass collection *1887* from Montana. Introgression of var. *dictyota* with var. *clavata* may occur: two collections of the latter, from Gray's Harbor County, Washington, (*Heller 4015,* US) and from Juneau, Alaska, (*Anderson 469*, NY) have the unlobed, irregularly serrate-margined leaves of var. *dictyota*.

Jepson's specimen (ND-G 5136), the holotype and only collection of this variety from the Lower Sacramento River in California, is a very stout, branched individual having a few badly withered leaves. Its fruits and pedicels match perfectly the Leiberg specimens from Idaho. Whether var. *dictyota* has a natural range from the Columbia River to the Sacramento Valley is unknown. This distribution is likely since some segregates of *R. curvisiliqua* extend from the lower Columbia to the Central Valley of California. Variety *dictyota* may also represent an introduction into the San Francisco area.

DISTRIBUTION: Map 16; 20-T.

20g. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. GLABRA (O. E. Schulz) Stuckey var. **fernaldiana** (Butters et Abbe) Stuckey, comb. nov.

Rorippa islandica (Oeder ex Murray) Borbás var. *fernaldiana* Butters et Abbe, Rhodora 42: 28. 1940. (Holotype: MAINE: [Aroostook Co.]: Wet places about the mouth of Aroostook River, Ft. Fairfield, 6 Jul 1893, *M. L. Fernald s.n.*, MIN. Isotype NEBC! Photo at MICH! OS!)

Rorippa palustris (Linnaeus) Besser var. *glabrata* (Lunell) Marie-Victorin f. *aquatica* Marie-Victorin, Contr. Inst. Bot. Univ. Montréal 17: 15. 1930. (Holotype: QUEBEC: Wet shores of Lake Champlain, Philipsburg, 10-11 Aug 1923, *C. H. Knowlton s.n.*, GH.)

Rorippa islandica (Oeder ex Murray) Borbás subsp. *fernaldiana* (Butters et Abbe) Hultén, Arkiv för Botanik 7: 61. 1968.

Rorippa palustris (Linnaeus) Besser subsp. *fernaldiana* (Butters et Abbe) Jonsell, Symb. Bot. Upsal. 19: 158. 1968.

ILLUSTRATIONS: Fassett (1940, p. 229, fig. 4); Fernald (1940, opposite p. 26, pl. 605, fig. 2) photograph of siliques; Fernald (1950, p. 715, fig. 1109), siliques; Gleason (1952, p. 239), as *R. islandica* and as var. *fernaldiana*; Gray (1849a, p. 132, pl. 53, fig. 1-5), flower parts; Hitchcock & Cronquist (1964, p. 538), as var. *glabrata;* Marie-Victorin (1930, p. 14, fig. 8), as *R. palustris* var. *glabrata*—probably drawn from one of the intermediates between var. *fernaldiana* and var. *glabrata*; Marie-Victorin (1947, p. 264), as *R. palustris* var. *glabrata*; Muenscher (1942, p. 272, fig. 50, E-F); Murley (1951, p. 72, fig. 20), seed; Pammel & King (1926, p. 166, fig. 90), photograph; Pammel & King (1926, p. 464, fig. 298), seed—poor!; Pammel, King & Hayden (1930, p. 158, fig. 1, p. 159, fig. 2, p. 160, fig. 3), photographs of rosette and plants; Steyermark (1963, p. 759, pl. 185, no. 5); Strausbaugh & Core (1953, p. 433), as *R. islandica*.

Variety *fernaldiana* is distinct with its short-cylindrical to ellipsoid siliques constricted at the center. Because of the constricted fruit, the replum has a concave margin and when dry becomes twisted. The expanded stigma is usually well developed. In the northern part of the range of var. *fernaldiana*, especially where it overlaps var. *hispida*, the lower stem and upper leaf surface are sparingly to quite hirsute. Southward in the United States, away from var. *hispida*, the leaves and stem tend to become glabrous. In this character there is apparent introgression between the varieties.

Early eastern North American literature did not distinguish between the European plant and the eastern North American segregates prior to Fernald (1928), Marie-Victorin (1930), and Butters and Abbe (1940). Thus there has been confusion between var. *palustris* and var. *fernaldiana*, not only as to distinguishing characters, but also which plants were native and which introduced. Britton (1891) wrote that var. *hispida* was common in eastern United States, and that "*N. palustre* is rarely met with and occurs only in situations where it has been introduced." Later, he (1901) wrote of *Roripa* [sic] *palustris*: "nearly throughout N. Am. . . Apparently nat. from Europe." He doubtlessly had plants of both var. *palustris* and var. *fernaldiana* in mind. There is no evidence that var. *fernaldiana*, although widespread and abundant in many artificially disturbed habitats in eastern North America, is introduced from Europe. According to Jonsell (in litt., 5 Oct 1964), var. *fernaldiana* has "never been reported from among European *R. islandica* [*R. palustris*]." Two very early specimens from western United States certainly suggest the plant was not introduced there from Europe or even from eastern United States: TEXAS: [Bexar Co.], San Antonio, Apr 1853, *G. Thurber s.n.* (NY, PH). WYOMING: [Converse Co.], mouth of Deer Creek, 26 Jul 1842, *Fremont s.n.* (NY). Furthermore, var. *fernaldiana* merges with var. *dictyota*, var. *glabra*, and var. *glabrata* in western Montana, and with var. *glabrata* in the St. Lawrence River valley. Variety *fernaldiana* may have originated out of the morphologically diverse complex in western Montana. With the Missouri and Platte rivers as avenues for migration, it moved east until now it is common in the Mississippi valley and the Great Lakes area, east to New England. This distribution appears to have come about by both natural and artificial means. There are many old (ca. 1830-1860) collections of this variety from eastern United States. In those days var. *fernaldiana* probably was confined to naturally disturbed areas about ponds and along rivers. However, with more man-created disturbed sites, this plant has very probably spread and become more abundant and aggressive in eastern United States. Pammel, King, and Hayden (1929, 1930) discussed the behavior and occurrence of this variety in Iowa grain fields. In a field study in the Douglas Lake region, of Michigan, I showed, by using a differential phytosociological table, that var. *fernaldiana* grows primarily with both introduced and native annual and introduced perennial plants in artificially disturbed habitats; in contrast, var. *hispida* grows almost entirely with native perennial plants in naturally disturbed habitats such as creek banks and sandy beaches (Stuckey, 1966a). This evidence suggests that man has aided in the spread (and perhaps the original introduction) of var. *fernaldiana* in the Douglas Lake region. Where var. *fernaldiana* is established in disturbed habitats where var. *hispida* grows, hybridization between the two occurs. This is discussed in the section on hybridization in *R. palustris*.

The disjunct distribution of var. *fernaldiana* in Florida leads me to suspect that the plants from the southern tip may represent introductions. Collections from Puerto Rico, Central America, and Colombia apparently are introductions, as they often are from roadsides, gardens, or along railroads.

DISTRIBUTION: Map 16; 20-U.

20h. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. GLABRA (O. E. Schulz) Stuckey var. **glabrata** (Lunell) Stuckey, comb. nov.

Rorippa hispida (Desvaux) Britton var. *glabrata* Lunell, Bull. Leeds Herb. 2: 6. 1908. ("Stem creeping on the ground. Found near Dunseith, Rolette Co., N[orth] D[akota]." Butters and Abbe apparently selected a lectotype from Lunell's collections at MIN, Rhodora 42: t.588. 1940. Lectotype: NORTH DAKOTA: Benson Co.: Leeds, 1 Jul 1907, *J. Lunell s.n.*, MIN 496. Topotypes, Leeds, 1 Jul 1908 & 27 Jun 1909, both *J. Lunell s.n.*, NY!)

Rorippa palustris (Linnaeus) Besser var. *glabrata* (Lunell) Marie-Victorin, Contr. Inst. Bot. Univ. Montréal 17: 15. 1930.

Rorippa islandica (Oeder ex Murray) Borbás var. *glabrata* (Lunell) Butters et Abbe, Rhodora 42: 28. 1940.

ILLUSTRATIONS: Butters & Abbe (1940, opposite p. 25, pl. 588), photograph of lectotype; Hitchcock & Cronquist (1964, p. 538), as var. *occidentale*.

My interpretation of var. *glabrata* differs from that of Butters and Abbe (1940). They interpreted Lunell's var. *glabrata* as a nearly glabrous segregate of var. *hispida* and included in it Nelson's concept of var. *globosa* and also a specimen from Santa Fe, New Mexico (*Heller 3743*, MO, MSC, NY, OC, US). The New Mexico plant has hirsute lower leaf surfaces and so is var. *hispida*. Fernald (1940) argued he could not maintain var. *glabrata* separate from var. *hispida*; var. *glabrata* has not been used since.

Variety *glabrata* differs from var. *glabra* and Nelson's var. *globosa* in having longer and wider fruits, and leaves rather thick, glossy textured, and glabrous on the upper surface (except for sometimes being slightly hirsute on the midrib). The photograph of the apparent lectotype selected by Butters and Abbe and their descriptions of it closely resemble the topotypes I saw in NY.

Variety *glabrata* is found in western Montana, where the basal leaves are quite large and greatly dissected. The uppermost cauline leaves are oblong and mostly entire, a feature not met elsewhere in North American *R. palustris*. In eastern Canada, the basal leaves and lower cauline leaves are less divided, often being unlobed or sinuate and irregularly serrate. The uppermost cauline leaves here are more lanceolate and are serrate. Specimens from the St. Lawrence River valley have the trichome distribution, the more slender silique constricted at the center, and the concave replum of var. *fernaldiana*; and the unexpanded stigma, glossy thick-textured glabrous leaves, and somewhat longer fruits of var. *glabrata*. They are indicated by "half circles" on map 16. Marie-Victorin's (1930) concept of *R. palustris* var. *glabrata* was founded on these intermediate plants. He misinterpreted an isotype of Rydberg's *R. integra*, took up this epithet in varietal rank under *R. obtusa*, and applied this name to some of the St. Lawrence plants. Fernald (1950) then included Marie-Victorin's *R. obtusa* var. *integra* as a valid member of the eastern North American flora.

DISTRIBUTION: Map 16; 22-V.

20i. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. GLABRA (O. E. Schulz) Stuckey var. **cernua** (Nuttall in Torrey et Gray) Stuckey, comb. nov.

Nasturtium cernuum Nuttall in Torrey et Gray, Fl. N. Am. 1: 74. 1838. ("Ponds of Wappatoo [Sauvies] Island at the junction of the Wahlamet [River] with the Oregon [River]." Holotype: OREGON: [Multnomah Co.]: Wappatoo Island, [ca. 1834, *fide* Pennell (Bartonia 18: 36. 1936), *Thomas Nuttall s.n.*], BM. Photo no. BM 2126, GH! PH! Isotype, PH! [The specimen was originally labeled "Nasturtium *cernuum N. amphibium affin."]

Variety *cernua* is very similar to var. *glabrata*, except that it is unique in its strongly recurved pedicels and very thick silique usually wider at the apex than the base. It occurs sparingly in northwestern United States and British Columbia but is more common in coastal Alaska, especially in the Aleutians. Collections from Banff, Alberta, and from Field, British Columbia, have siliques and basal leaves more nearly like those of var. *glabrata* of that region, but the pedicels are somewhat to rather strongly recurved. These collections are transitional between the varieties; they are designated as "open stars" on map 16. The var. *cernua* also intergrades with var. *clavata* in that some siliques, usually long for var. *cernua*, are quite clavate at the apex, and the pedicels are more nearly at right angles to the axis. A collection (*Anderson 6266*, PH) from Juneau, Alaska, represents this condition.

In a footnote in Watson's (1895) treatment of the genus, *N. cernuum* was cited as a synonym of *R. curvisiliqua*. All authors since have copied this error. That *N. cernuum* has recurved pedicels is evidence it does not belong to *R. curvisiliqua*, because the latter is one of the few species complexes in which such pedicels are not developed. Examination of both an isotype and a photograph of the holotype leaves no doubt that Nuttall described a plant with strongly recurved pedicels and a short thick fruit wider toward the apex. The type does differ somewhat from Alaskan specimens in having leaves more deeply divided and less thick; in these features it tends to approach var. *clavata*.

DISTRIBUTION: Map 16; 22-W.

20. iv. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. HISPIDA (Desvaux) Jonsell, Symb. Bot. Upsal. 19: 159. 1968.

Brachilobus [sic] *hispidus* Desvaux, Jour. Bot. 3: 183. 1814. ("Hab[itat] in Pennsylvania. Je n'ai observé cette plante que dans l'herbier de M. de Beauvois." Type not seen.)

Sisymbrium hispidum (Desvaux) Poiret in Lamarck, Encyc. Suppl. 5: 161. 1817.

Nasturtium hispidum (Desvaux) A. P. DeCandolle, Syst. Nat. 2: 202. 1821.

Nasturtium palustre β hispidum Fischer et Meyer, Ind. Sem. Hort. Petrop. 3: 41. 1837. [Fischer et Meyer do not cite any author for their epithet. Presumably it is based on Desvaux.]

Nasturtium palustre ("Leysser" [Linnaeus]) A. P. DeCandolle var. *hispidum* (Desvaux) Gray, Man. ed. 2. 30. 1856.

Cardamine palustris ("Leysser" [Linnaeus]) O. Kuntze *ζ hispida* ("A. P. DeCandolle" [Desvaux]) "Fischer et Meyer" [O. Kuntze], Rev. Gen. 1: 25. 1891.

Roripa [sic] *hispida* (Desvaux) Britton, Mem. Torrey Club 5: 169. 1894.

Roripa [sic] *palustris* [(Linnaeus) Besser var.] *hispida* (Desvaux) Rydberg, Bot. Surv. Neb. 3: 26. 1894; reprint, Contr. U. S. Natl. Herb. 3: 149. 1895.

Nasturtium terrestre (Withering) R. Brown in Aiton var. *hispidum* (Fischer et Meyer) B. L. Robinson in Gray, Syn. Fl. N. Am. 1: 148. 1895.

Nasturtium palustre ("Leysser" [Linnaeus]) A. P. DeCandolle subsp. *hispidum* (Desvaux) "Fischer et Meyer" [O. E. Schulz], Symb. Antill. 3: 515. 1903.

Radicula hispida (Desvaux) Britton, Torreya 6: 30. 1906.

Radicula palustris (Pollich) Moench var. *hispida* (Desvaux) B. L. Robinson, Rhodora 10: 32. 1908.

Roripa [sic] *terrestris* ("R. Brown in Aiton" [Withering]) A. Nelson [var.] *hispida* (Desvaux) A. Nelson, Bot. Gaz. 52: 264. 1911.

Nasturtium hispidum (Desvaux) A. P. DeCandolle f. *genuinum* N. Busch, Fl. Sib. et Orient. Extr. 15: 207. 1915.

Rorippa palustris (Linnaeus) Besser var. *hispida* (Desvaux) Rydberg f. *inundata* Marie-Victorin, Contr. Inst. Bot. Univ. Montréal 17: 16. 1930. (Holotype: MAINE [Penobscot Co.]: Gravelly shores, Piscataquis River Valley, Foxcroft, 5 Sep 1894, *M. L. Fernald s.n.*, GH. Isotype, NEBC! Photo at MICH! OS!)

Rorippa islandica (Oeder ex Murray) Borbás var. *hispida* (Desvaux) Butters et Abbe, Rhodora 42: 26. 1940.

Plants stout, 4-10 dm. tall, stems thick, mostly over 3 mm. in diameter, densely to sparingly hirsute below, becoming sparingly hirsute to glabrous above; leaves hirsute on both surfaces; petals shorter or longer than the sepals; stigma usually unexpanded.

Key to Varieties of Subspecies hispida

1. Siliques globose to subglobose, (2.2)2.6-5(6.7) mm. long, 1.3-2.6(3.1) mm. wide, ca. 1-2 times as long as wide; replum circular to elliptic in outline;

petals 1-1.5(2) mm. long; pedicels 2.7-5.5(8.6) mm. long, usually divergent to ascending; stem usually densely hirsute below. . 20j. var. *hispida*

1. Siliques elongate-cylindrical, (3)5.2-7.8(8.5) mm. long, (1.4)2.1-3.1 mm. wide, ca. 2 or more times as long as wide; replum oblong in outline; petals 1.5-2(2.8) mm. long (if siliques less than 5 mm. long, then petals 1.7-2.5 mm. long); pedicels (3.8)4.2-7.8(12) mm. long, usually divergent to recurved; stem usually sparingly hirsute below. . 20k. var. *elongata*

20j. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. HISPIDA (Desvaux) Jonsell var. HISPIDA

ILLUSTRATIONS: Abrams (1944, p. 281, fig. 2028); Britton & Brown (1897, p. 125, fig. 1718; 1913, p. 161, fig. 2031); Fassett (1940, p. 229, fig. 1, 3); Fernald (1940, opposite p. 261, pl. 605, fig. 4-8), photographs of siliques; Fernald (1950, p. 715, fig. 1110), siliques; Gleason (1952, p. 239), as var. *hispida*; Hitchcock & Cronquist (1964, p. 538), as var. *hispida*; Marie-Victorin (1947, p. 264), as var. *hispida*.

Globose to subglobose siliques, slender style with an unexpanded stigma in fruit, and the basal and cauline leaves hirsute on the lower surface distinguish var. *hispida*. In eastern United States, particularly Wisconsin and Michigan, the stigmas are often somewhat expanded in fruit, perhaps through introgression from var. *fernaldiana*. In the southern Rocky Mountains, where var. *hispida* grows in the absence of var. *fernaldiana*, the stigma is definitely unexpanded. I previously pointed out distinctions between the two varieties (Stuckey, 1966a).

Variety *hispida*, common in the Rocky Mountains, becomes scattered southward to Dona Ana County, New Mexico, and westward to northeastern California and southern Oregon. I have not seen specimens forming the basis for attributing this entity to Arizona (Kearney and Peebles, 1951) and to the Sonoran Desert (Shreve and Wiggins, 1964). In eastern United States, var. *hispida* is almost confined to north of the southern limit of Wisconsin glaciation. Contrary to eastern North American manuals (Fernald, 1950; Gleason, 1952), var. *hispida* does not grow as far south as Florida and Texas. It is evident, from Fernald's annotations on specimens at GH, he did not know the differences between var. *hispida* and var. *fernaldiana*. All specimens seen from Florida, Missouri, West Virginia, and Texas, misidentified as var. *hispida*, are var. *fernaldiana*. Steyermark's (1963) discussion and map of var. *hispida* and his specimens at MO labeled var. *hispida* should be referred to var. *fernaldiana*. The map of var. *hispida* in Patman and Iltis (1961) is correct except that vouchers for LaCrosse and Wood counties are var. *fernaldiana*, as are the vouchers for Clermont and Noble counties in Ohio on Easterly's map (1964). Records for West Virginia (Strausbaugh and Core, 1953) based on specimens at WVA are var. *fernaldiana*. I have not checked the vouchers for Deam's (1940) Indiana map and Jones and Fuller's (1955) Illinois records. These records are probably correct, although Deam lists a Coulter collection from Jefferson County, south of the glacial border. If correctly identified it may represent either a migrant from upstream on one of the tributaries of the Ohio River or an introduction.

DISTRIBUTION: Map 17.

20k. RORIPPA PALUSTRIS (Linnaeus) Besser subsp. HISPIDA (Desvaux) Jonsell var. **elongata** Stuckey, var. nov. (Holotype: MONTANA: Deer Lodge Co.: Locally common in wet field adjacent to creek bank and railroad track along U. S. highway 10, ca. 9 mi s of Deer Lodge, ca. 4700 ft [ca. 1410 m], 13 Jul 1963, *R. L. Stuckey 1882*, MICH! Fig. 7. Isotypes to be distributed.)

Herba annua erecta; siliquis elongato-cylindricis (3)5.2-7.8(8.5) mm. longis, (1.4)2.1-3.1 mm. latis; replis elongato-oblongis; petalis 1.5-2(2.8) mm. longis; pedicellis (3.8)4.2-7.8(12) mm. longis diversis vel recurvatis; caulibus infra vulgo sparse hirsutis.

ILLUSTRATION: Fig. 7.

Previous authors (Busch, 1915; Hultén, 1945) treated these plants under a combination of the name *hispida* based on Desvaux's type. It is evident from characters and measurements given by Rydberg (1922) and from his annotations on specimens at NY that he was using the name *Radicula pacifica* (Howell) Greene for these plants. Howell (1897) proposed the epithet *pacifica* to replace *occidentalis*, a name based on a type representing a different segregate in *R. palustris*, when he wanted to raise *occidentalis* to specific rank—thus avoiding creation of a later homonym of *Roripa* [sic] *occidentalis* (Greene) Greene.

Variety *elongata* is characterized by those plants from the Pacific coastal United States, across to Montana, North Dakota, and along the Gulf of the St. Lawrence. These have siliques over 6 mm. long, mostly equal to the length of the divergent to recurved pedicels. Included also are plants very similar in fruit size from northwestern Canada. In this area there also occur a few plants with siliques much shorter (down to 3 mm.). These short-fruited plants differ in several ways from var. *hispida*: the siliques are cylindrical rather than globose and are on much longer pedicels (ca. 6-12 mm. long, ca. 2-4 times as long as the siliques); and the petals are extremely long (ca. 1.7-2.5 mm.). They perhaps represent another segregate in *R. palustris* radiating from a center of diversity in Alaska or Asia. Until we know more about limits and total range of these variations in Alaska and eastern Asia, I have temporarily identified these short-fruited plants as var. *elongata*. Their localities are designated by "half-solid circles" on map 17.

Variety *hispida* occurs sparingly north to Alaska; var. *elongata*, sparingly south into the Rocky Mountains. These rare occurrences of one variety deep in the range of the other may be the result of unusual genetic combinations in the population, producing a plant with characteristics of the geographically distant variety.

Another problem is that several specimens, particularly those from areas where var. *williamsii* occurs in Alaska, have an expanded stigma. Throughout subsp. *hispida*, the stigma is unexpanded, except where influenced by hybridization and apparent introgression with var. *fernaldiana*. In Alaska,

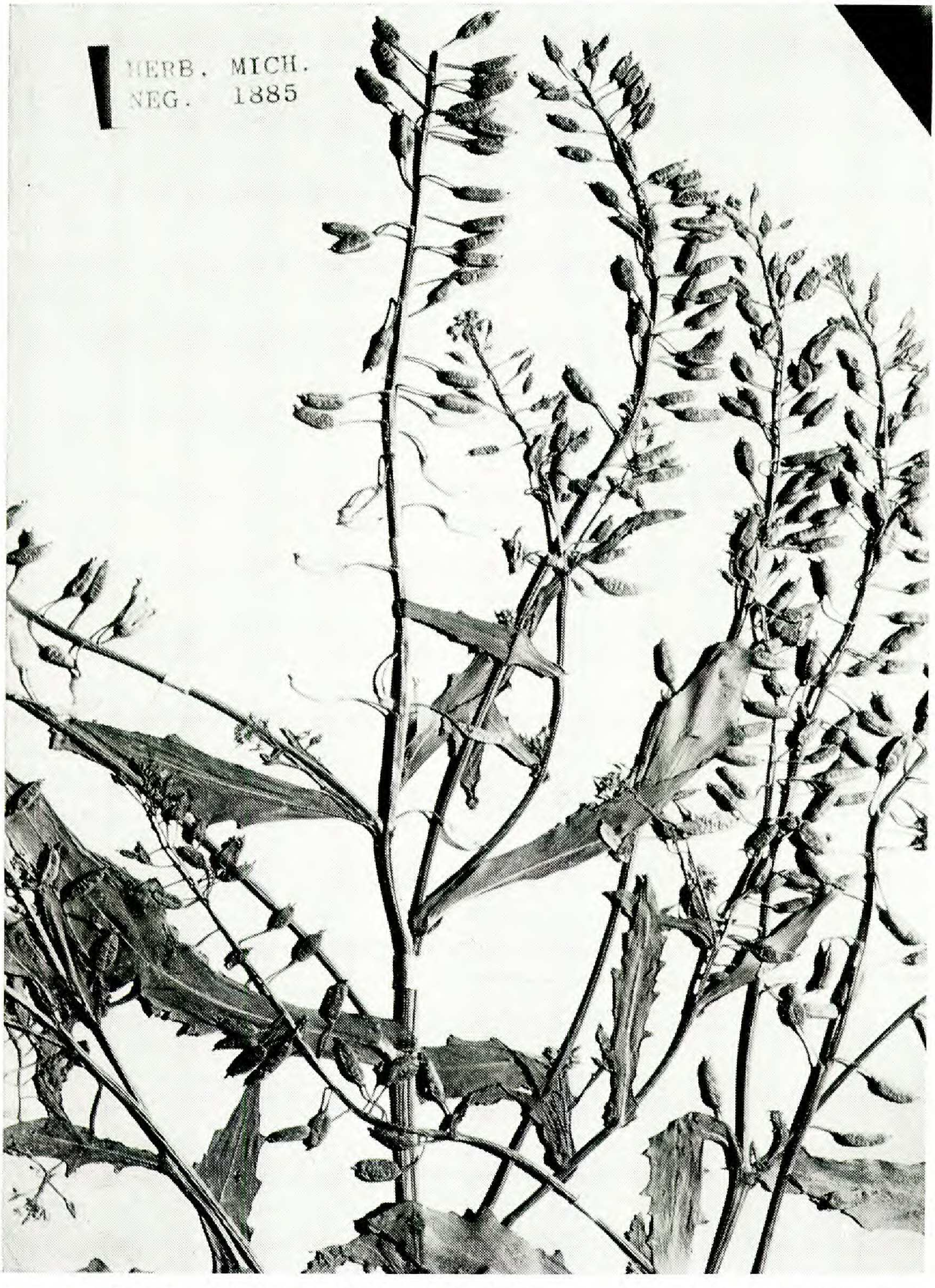


Fig. 7. Photograph of a portion of the holotype of *Rorippa palustris* (Linnaeus) Besser subsp. *hispida* (Desvaux) Jonsell var. *elongata* Stuckey. (*R.L. Stuckey 1882*, MICH). Univ. Mich. Neg. No. 1885.

then, there may be hybridization or introgression between var. *elongata* and var. *williamsii*. Hultén (1945) cited three specimens he thought to be hybrids. I have not seen them. Based on evidence of hybridization in the eastern North American segregates of *R. palustris*, we might expect a hybrid plant to combine fruit characters of var. *williamsii* with trichome characters of var. *elongata*. Thus hirsute plants with an expanded stigma may very well be hybrids between these Alaskan inland segregates. That var. *williamsii* and var. *elongata* have similar-shaped fruits makes detection of hybrids more difficult than between taxa of different fruit types (e.g., var. *hispida* × var. *fernaldiana* or var. *hispida* × var. *palustris*). Some Alaskan plants I identified and mapped as var. *elongata* may represent hybrids. The following are examples of plants with expanded stigmas: ALASKA: *Hultén*, 20-22 Aug 1960, US; *Layden 24*, US; *Muller 1137*, *1138*, US; *Raup 545*, US. YUKON: *Malte 35*, US. Only with many more specimens from areas where the two grow together and do not grow together, field work, and experimental crosses can this problem be attacked. Porsild (1951) wrote that "totally glabrous and moderately hispid plants may be seen growing side by side." We need population samples from these situations.

The occurrence of var. *elongata* in eastern North America requires discussion. Fernald (1940) reported, under the name *R. barbareaefolia*, two specimens from the Gulf of St. Lawrence that properly are var. *elongata*. He stated that this taxon was another one common to the floras of the Gulf of St. Lawrence and of the northern Pacific. I have seen duplicates of one of the collections he cited (*Marie-Victorin & Rolland-Germain 21439*, PH, US); Fernald correctly interpreted the plant as being like one of the *R. palustris* segregates of the Pacific Northwest. A collection of this variety from Labrador (*Waghorne 19*, US) matches perfectly a specimen from Washington, (*Sandberg & Leiberg 509*, US).

I grew plants of var. *hispida* from Michigan (including *Stuckey 1068*) and var. *elongata* from Montana (*Stuckey 1882*) under similar greenhouse conditions; characters distinguishing the two were maintained.

DISTRIBUTION: Map 17.

HYBRIDIZATION IN RORIPPA PALUSTRIS

From observation and experimentation on *R. palustris* var. *hispida* and var. *fernaldiana* grown at The University of Michigan Biological Station and at The University of Michigan Botanical Gardens in 1962, I determined that these varieties of *R. palustris* are self-pollinating and self-fertile. Seeds of var. *hispida* from Burt Lake, Cheboygan County, Michigan (*Stuckey 1068*) and seeds of var. *fernaldiana* from 4 miles north of Pellston, Emmet County, Michigan (*Stuckey 1099*) were planted in February 1963. By August the plants were in flower. I removed the anthers from several flower buds about to open on a plant of var. *hispida*, took off all other young buds and opened flowers, transferred pollen from var. *fernaldiana* to the stigmas of the emasculated flowers, and covered the inflorescence with a 4 × 10 cm. fine muslin bag fitted with a draw thread to keep out insects and foreign pollen. The bag was removed February 6, 1964; about 60 seeds had formed. These were planted in April 1964, and 35 young plants were grown until they flowered and fruited in summer 1964. All these F_1 hybrids were extremely hirsute on the lower stems, the lower leaf surface was hirsute, and the pedicels were ascending—distinguishing characters of var. *hispida*. The fruits were cylindrical and constricted at the middle, and the stigma, although less than in some plants of var. *fernaldiana*, was somewhat expanded—distinguishing characters of var. *fernaldiana*. The hybrid plants, self-fertile, set seed well.

Gleason (1952) pointed out that "numerous plants combine some degree of pubescence with cylindric fruit, or glabrous foliage with short ovoid fruits." I discussed plants of the latter type under var. *glabra*, but this variation has not been found in eastern North America. Plants of the former type are undoubtedly hybrids between var. *hispida* and var. *fernaldiana*. These specimens, with hirsute lower leaf surfaces and cylindrical fruits, occur only in eastern North America mostly north of the southern limit of Wisconsin glaciation (map 18), where both var. *hispida* and var. *fernaldiana* grow. Where var. *hispida* (in the Rocky Mountains) and var. *fernaldiana* (in southeastern United States and the lower Mississippi River valley) grow alone, pubescent plants with cylindrical fruits are not found. Because plants with the same character combination as the known hybrid occur only where both parents grow, a hybrid origin for these plants is almost certain.

Dr. James S. Pringle of the Royal Botanical Gardens, Hamilton, Ontario, called to my attention a population of extremely variable plants of the two varieties at Cornwall Lake, Cheboygan County, Michigan. Mr. Chester W. Laskowski made a mass collection from this population for me in summer 1964, and later (30 July 1964) we visited the lake and I obtained more specimens. Plants representing good var. *hispida* (*Stuckey 2382*) and good var. *fernaldiana* (*Stuckey 2383*) were abundant, but plants matching the artificial hybrid were also found (*Stuckey 2384*). Some plants, intermediate between parents and hybrid, indicated a hybrid swarm. On 4 August 1964, I found one plant (*Stuckey 2416*) at Duncan Bay, Cheboygan County, Michigan, like my artificial hybrid. It grew with var. *hispida* (*Stuckey 2415*) and var. *fernaldiana* (*Stuckey 2414*). From these observations, it appears that when the more aggressive and weedy var. *fernaldiana* reaches disturbed sites where var. *hispida* grows, hybrids may be formed.

In fall 1964 I planted seeds from the artificial hybrid and from collections *2416* and *2384*. Among the F_2 plants, 73 were from the artificial hybrid, 32 were from *2416*, and 36 were from *2384*. In the basal rosette stage, the lower leaf surfaces of some plants were glabrous, others were extremely hirsute, and still others possessed varying degrees of pubescence. The complete spectrum of variation was represented. Because these plants were grown in winter under short days when *Rorippa* does not flower, it was necessary to provide artificial light so they would receive at least 16 hours of light per day. Plants placed directly under the light produced well-formed inflorescences and fruits. Plants at some distance from it were stunted and "attempted" to flower and fruit—fruits were either poorly formed or not formed. Among plants receiving best direct light, fruit size and shape were extremely variable. The F_2 plants of each of the three hybrid groups possessed characters of good var. *hispida* through various intermediates to good var. *fernaldiana*. These plants were not further studied although vouchers exist (OS). These observations reveal that when offspring of two plants of suspected hybrid origin from different wild populations are grown, they form a series of variants similar to offspring of a known hybrid. Wild plants combining characters of both varieties are undoubtedly of hybrid origin.

Fernald (1948a) named a form (f. *reptabunda*) of *R. islandica* var. *microcarpa*. He used the epithet *microcarpa* in varietal rank for the plant previously described as var. *fernaldiana* (Butters and Abbe, 1940); later, he (1948b) corrected this error. I examined the type of this form at GH; it is a plant with hirsute lower leaf surfaces and cylindrical fruits with an expanded stigma. It is evidently of hybrid origin between var. *hispida* and var. *fernaldiana* and therefore should not be retained as a form of var. *fernaldiana* but designated a hybrid as follows: RORIPPA PALUSTRIS (Linnaeus) Besser subsp. HISPIDA (Desvaux) Jonsell var. HISPIDA × subsp. GLABRA (O. E. Schulz) Stuckey var. FERNALDIANA (Butters et Abbe) Stuckey, or designated as RORIPPA PALUSTRIS (Linnaeus) Besser var. × **reptabunda** (Fernald) Stuckey, hybr. var., comb. nov.

The synonymy is as follows:

Rorippa islandica (Oeder ex Murray) Borbás var. *microcarpa* (Regel) Fernald f. *reptabunda* Fernald, Rhodora 50: 35. 1948. (Holotype: NEW HAMPSHIRE: Coos Co.: Muddy shore of Nash Stream Bog, Odell, 27 Aug 1947, *A. S. Pease 33162*, GH! Isotype, US in part! Photo at MICH! OS!)

Rorippa islandica (Oeder ex Murray) Borbás var. *fernaldiana* Butters et Abbe *f. reptabunda* (Fernald) Fernald, Rhodora 50: 100. 1948.

Locations of hybrid plants are shown in map 18.

Where the ranges of var. *palustris* and var. *hispida* overlap in the Thunder Bay District, Ontario, a few plants combine the characters of the varieties. These plants have thin dissected leaves with purple cast and a slender purple stem—characters of var. *palustris*. The fruits are globose to subglobose (though sometimes stunted); the stigma is unexpanded; and the upper leaf surfaces are hirsute—characters of var. *hispida*. Because these plants combine characters of the varieties in a manner similar to that of the artificial hybrid var. *hispida* × var. *fernaldiana*, I conclude that they are also of hybrid origin: RORIPPA PALUSTRIS (Linnaeus) Besser subsp. PALUSTRIS var. PALUSTRIS × subsp. HISPIDA (Desvaux) Jonsell var. HISPIDA. Localities of these plants are shown in map 18.

A natural first generation hybrid has been reported between *R. palustris* ["*R. islandica*"] and *R. barbareifolia* (Mulligan & Porsild, 1968).

AN INTERPRETATION OF THE DISTRIBUTION OF RORIPPA PALUSTRIS

I have pointed out that there are areas in western United States where

Rorippa shows much morphological diversity, either within a species or among a group of closely related species. *Rorippa palustris* is morphologically diverse in the Rocky Mountains in western Montana, northern Idaho, southern British Columbia, and southern Alberta, and from there segregates radiate. However, this may not be the only center of diversity for *R. palustris*. Possible centers are in Alaska or elsewhere in the Bering Sea region and in Asia (see Butters and Abbe, 1940, p. 29, who comment that fruit distinctions break down in a region between Lake Baikal and the Pacific). The nature and location of such possible centers can hardly be discussed because I have not seen enough material and have not had field experience there. Because *R. palustris* is widespread throughout boreal regions, its distribution has doubtless been modified by glaciation, which may have obliterated any previous center or centers. The centers today may merely be subcenters which were survivia for various segregates during maximum glaciation; from these, northern North America may have been repopulated. However, I think that the Rocky Mountain center of northern United States may be an original one. My reasons follow.

(1) This center has contributed segregates that migrated into and populated areas far south of the southern limits of glaciation. These areas may have become populated when certain segregates in related species were invading and becoming established. A center in Asia or Alaska, more distant, would be less likely to contribute segregates to these areas.

(2) In the northern Rockies of the United States and southern Canada, nearly all the character combinations and therefore nearly all the taxonomic entities in North American *Rorippa* are found, as are plants morphologically intermediate and unassignable to any taxon (e.g., MONTANA: Sanders Co., Noxon, *Stuckey 1897*, MICH).

(3) That only one segregate is known in western Europe points to an origin elsewhere. The var. *palustris* of Europe is entirely different from other *Rorippa* of that region. A winter annual, it grows singly from a taproot, has petals shorter than the sepals, and has short globose anthers; whereas other species (except *R. islandica*) of western Europe, *R. amphibia*, *R. sylvestris*, and *R. prostrata*, are perennial, spread by roots and stems, have petals longer than the sepals, and have elongate anthers. From what we know about evolution in these characters in North American *Rorippa*, these European species are very different and probably represent another line of evolution. Therefore the origin of European var. *palustris* ought to be looked for in North America. One specimen of var. *palustris* is known from the Rocky Mountain center of diversity.

(4) Plants most similar morphologically to *R. palustris* or, in other words (based on the reasoning throughout this paper), its closest relatives, are in the mountains of western United States. *Rorippa curvipes* var. *integra* is most similar to *R. palustris*, and this variety is also very close to *R. curvisiliqua*. Thus the three well-developed centers of diversity in western United States are linked together morphologically by a taxon lying geographically among them.

(5) This Rocky Mountain center of diversity, geologically old, has been available for plants for millions of years. There have been sufficient time and available space for the segregates to come into existence. This area, at the southern limit of the continental ice sheet, was partially unglaciated, thereby providing a survivium for plants during the unfavorable eras of glaciation.

(6) The general drainage pattern is outward and away from this center of diversity. Thus an ideal avenue for migration does exist and has probably been a factor in producing the distribution patterns of today, not only in *R. palustris* but also in the varieties of *R. curvisiliqua* and members of the *R. curvipes* complex. In *R. palustris*, for example, the Columbia River has aided the westward spread of var. *dictyota* and var. *cernua*; the Missouri and its tributaries and then eventually the Mississippi have aided the eastward and southward spread of var. *fernaldiana.* The Saskatchewan River has doubtless aided the eastward movement of var. *palustris* and probably var. *glabrata.*

Whereas it seems probable that the segregates in western United States and var. *fernaldiana* in southeastern United States may have spread from the Rocky Mountain center at an early time, the segregates to the north were apparently influenced by glaciation, and this event has had a marked effect on distribution of these segregates. A plausible explanation for distribution patterns of the northern segregates as related to glaciation was advanced by Hultén (1937).

Upon mapping and comparing distributions of plants of northeastern Asia and northwestern North America, Hultén (p. 25) found several centers of distribution there. One of his centers in North America is in the state of Washington—nearly coincident with two centers of diversity in *Rorippa.* His centers coincide with areas totally or partially unglaciated; he found no centers in northern Europe, western Siberia, northeastern America, or between the Yukon valley and the Great Lakes—glaciated areas. According to Hultén, apparently no plants spread from these latter regions, which were covered with ice during maximum Pleistocene glaciation, but rather the plants spread over arctic and boreal regions from centers or refugia [survivia] close to the ice, where they possessed a small part of their earlier area and survived the severe conditions of maximum glaciation (p. 25).

With respect to boreal circumpolar plants, among which he included *Rorippa palustris* (*Nasturtium palustre*), Hultén assumed that the plants "already occupied at least the greater part of their present area earlier than the maximum glaciation and that this old area was split up into parts separated from one another by heavy glaciation or by districts with such severe climatic conditions during maximum glaciation that the species concerned were exterminated there" (p. 42). Boreal circumpolar plants "were so sensitive to cold that they were able to survive chiefly on the refugia [survivia] south of the ice" (p. 118). "Different races of a species must have been formed under the influence of the ice" (p. 47). Thus, great diversity of races or segregates in boreal circumpolar plants is natural because the glaciated area was filled by radiants from centers isolated from remnants of the old area; from these centers different races or segregates spread, completely or partially filling the gap between the centers. Hultén outlined on a northern hemisphere map the major elementary areas or refugia [survivia] (p. 119, fig. 11). These refugia [survivia] corresponded, at least in part, to the centers he had found and which were referred to earlier. In North America, Hultén had refugia [survivia] in the Aleutian Islands and southern coast of Alaska, the Rocky Mountains of northern United States and western Canada, the Great Lakes region, and around the mouth of the St. Lawrence River.

In using Hulten's hypothesis, one assumes that the species had a distribution throughout boreal North America before the last ice age. We may, indeed, infer from present distribution of subspecies *hispida* that *R. palustris*, at least in part, was widespread throughout boreal America before glaciation (subspecies *hispida* is found today on unglaciated areas in eastern and western North America; between these areas, it is virtually confined to glaciated territory). *Rorippa palustris* is tremendously variable in the Rocky Mountains of northern United States and southern Canada. This region of diversity corresponds to one of Hultén's elementary areas, and we may conclude that in it various segregates of North American *R. palustris* lived during glaciation as the surviving segregates of more widespread pre-glacial populations. Very possibly, new segregates arose through hybridization in the same area and habitats. Although portions of the Rocky Mountains were doubtless glaciated during Wisconsin glaciation, Hultén says that "glaciation was not heavy, and many plants were able to survive there" (p. 52).

What did *R. palustris* do during retreats of the continental glaciers? I would regard it as a "plastic species" (Hultén's term); many of its segregates would move outward from their center, filling available habitats. Thus in each area, natural selection apparently operated so that each segregate was able to migrate, colonize, and survive further outward from the center without the immediate influence of other biotypes. The ultimate, of course, is the present distribution of *R. palustris* in boreal North America.

On the whole, *Rorippa* is a genus of pioneer plants, often the first to colonize a low, wet, denuded area. In northern Ohio and Michigan var. *fernaldiana* is one of the first plants to colonize the edge of a new farm pond or cleaned-out drainage and roadside ditches. Quite common during the first couple of years in these habitats, var. *fernaldiana* is soon crowded out and eventually disappears. *Rorippa* seeds germinate most readily in moist, open, warm places. Rosettes and plants are usually not found in shaded areas or where vegetation is dense. The plants apparently do not compete well. Although such observations have been made mostly on var. *fernaldiana*, the same biological processes appear at work in other segregates of *R. palustris* as well as in other species of the genus (see also Jonsell, 1968, p. 3).

At the time of Wisconsin glacial retreat, streams and rivers were either enlarged or formed anew as the meltwater became abundant. Moraines and alluvial deposits dotted the landscape, but the soils were bare. Stranded bodies of water formed lakes. A perfect avenue for migration and colonization by pioneer plants had been created. Adjacent to these newly exposed areas were the survivia with the various segregates. *Rorippa palustris* was one of those species with many segregates. A short-lived pioneer plant, it doubtless spread rapidly as seeds, carried by wind and water to the fresh barren soils, germinated, and probably grew in abundance. The var. *hispida*, one of those segregates surviving glaciation in the Rocky Mountains, was extremely successful when its offspring began to colonize areas left newly vacant. Migration was probably outward through the region of the present upper Missouri River. That var. *hispida* is not found south of the southern limit of Wisconsin glaciation in central United States may in part be explained by saying that the area was already populated with plants, and habitats void of vegetation were few, much as they are today—mainly river banks and pond shores. Thus natural migration of a species poorly equipped to compete would be quite slow or non-existent through this region. The result is that var. *hispida* has penetrated only into Nebraska from the Rocky Mountains.

In glaciated territory, var. *hispida* had a nearly continuous avenue of exposed soil to colonize, and it was able to migrate across the continent from west to east. At the same time, other plants moved into the area and competition began and continued as part of succession. Higher lands were ultimately drained and much of the landscape became drier. The result was that var. *hispida*, no longer able to compete, died out in many places within its range, but it survives where soil is constantly being shifted and exposed, naturally-disturbed habitats where plants have difficulty in gaining a permanent foothold. In these habitats north of the southern limit of Wisconsin glaciation var. *hispida* survives—the last remnants of what must have been a much more abundant plant thousands of years ago. Today, var. *hispida* occasionally gets out of its natural habitat in eastern North America, probably with the help of man or other agents, and may be found in artificially disturbed sites.

Many collections of var. *hispida* from the Delaware River valley come from ballast or waste places; var. *hispida* may have been introduced there by migrating from the north. On the other hand, var. *hispida* was found in the mountains of eastern Pennsylvania at an early date when there was less disturbance and fewer chances for introduction, and it is certainly possible that it survived Wisconsin glaciation in the Appalachian Mountains or on the Atlantic Coastal Plain. Although it has been found in the Washington, D. C., area, it seems absent in other coastal areas in New Jersey, Delaware, and Maryland. If var. *hispida* survived in both eastern and western North America, it has remained essentially unchanged as I can find no differences between plants from the two areas except that some Colorado plants have slightly longer siliques. From a survivium in the Appalachians, it could have spread northward and westward. The occurrence of var. *hispida* south of the glacial boundary in Ohio and possibly Indiana (Deam, 1940, P. 495 map 1017) has apparently come about by migration of plants down river.

Variety *fernaldiana* would have survived glaciation in southeastern United States as well as in the Rocky Mountains. Upon the retreat of the Wisconsin glacier, plants of var. *fernaldiana* from these regions would have migrated onto territory once glaciated. Apparently in the glaciated region var. *hispida* and var. *fernaldiana* have been segregated ecologically and reproductively because they remain distinct. With the advent of European man in glaciated country, there were more disturbed habitats and more opportunity for the varieties to associate. Where the two occur together, hybrid plants are sometimes found, as discussed earlier and in Stuckey (1966a).

Since I wrote my thesis in 1965, Iltis (1965) discussed the idea of a western (Cordilleran) species migrating east onto glaciated territory and a southern (Appalachian) species migrating north onto it after the retreat of the Wisconsin glacier. He pointed out that a similar phenomenon has apparently occurred in *Gentianopsis* and other genera with east-west species pairs.

To return to the Rocky Mountain center of diversity, we can infer that var. *elongata* migrated west to the Pacific Coast in the United States and east at least to North Dakota. Variety *elongata* also occurs along the northeastern shore of the Gulf of St. Lawrence and on the Labrador coast. Fernald (1925) and Marie-Victorin (1938) would explain this disjunction by saying that before or during one of the interglacials, var. *elongata* had a continuous and uniform distribution from western to eastern North America, but it was obliterated by Wisconsin glaciation, surviving in the Rocky Mountains and on the limestone shelf that formerly existed, at least in part, along the north shore of the Gulf of St. Lawrence. Marie-Victorin (1938, p. 543) goes into some detail to explain his idea of the apparent habitats and conditions allowing these plants to survive. Marie-Victorin's idea is questionable on geological grounds, and some alternative ideas, particularly that of Wynne-Edwards (1937), who correlates distributions of this type with soil conditions, may bear further consideration.

One idea that Marie-Victorin (1938, p. 554) proposed, apparently in a passing reference, to explain the distribution of certain plants, particularly shore plants found in the Rocky Mountains and in isolated places on the northeast coast of the Gulf of St. Lawrence, was that these plants may have migrated along a "kind of side-walk." He wrote:

> But we can not round out all the facts without admitting more or less intricate and massive Pleistocene or post-Pleistocene migrations. Picturing the . . . unforested belt that must have existed along a receding ice-front, as a kind of side-walk extending from the Rockies to the Gulf of St. Lawrence, undoubtedly helps understand the presence of a good number of sea-level and highly isolated plants, of evident Cordilleran affinity.

I have not found anywhere that Marie-Victorin expanded upon this statement, but I think the west to east migration of var. *hispida* provides a good example of what he had in mind, and that var. *elongata* may have had a similar history.

Whether plants with similar distribution patterns have actually had a similar distributional history can be debated, especially if the plants belong to different ecological situations, vegetational types, or habitats. In my field work I noted several species that often grow with var. *hispida* on lake sandy shores. These associates often have a similar distribution pattern, although data are sometimes not complete or available. It seems that plants of similar habitats, ecological requirements, and distributions may likely have a similar distributional history. Study of the ecological requirements of these species may provide information to support the "side-walk hypothesis." The following show distributions or are believed to show distributions parallel to var. *hispida*, with which they have been found growing: *Juncus arcticus* subsp. *littoralis* [*Juncus balticus* var. *littoralis*] (E. Hultén, Sv. Vet-akad. Handl. IV. 8(5): 25. 1962); *J. alpinus* (E. Hultén, *ibid.*: 97. 1962); *Lycopus uniflorus* (N. C. Henderson, Am. Midl. Nat. 68: 108. 1962); and *Scirpus americanus*, *Potentilla anserina*, and *Solidago graminifolia* (no maps of their total distribution have been seen). These may be expected to occur with var. *hispida*: *Equisetum palustre*, *Carex viridula*, *C. aquatilis* subsp. *altior*, *C. diandra*, *Hierochloe odorata*, *Beckmannia eruciformis* [*B. syzigachne*] (E. Hultén, Sv. Vet-akad. Handl. IV. 8(5): 99, 171, 75, 129, 115, 173. 1962); *Lycopus asper* (N. C. Henderson, Am. Midl. Nat. 68: 127. 1962); and *Sagittaria cuneata* (C. Bogin, Mem. N. Y. Bot. Gard. 9: 226. 1955). A few strictly aquatic plants of similar distribution are: *Potamogeton zosteriformis*, *P. friesii*, *P. strictifolius* (M. L. Fernald, Mem. Am. Acad. 17: 37, 53, 56 and 58. 1932); and *P. natans*, *P. gramineus* var. *gramineus*, *P. praelongus*, and *P. richardsonii* (E. C. Ogden, Rhodora 45: 127, 147, 175. 1943).

Applying Hultén's (1937) idea to subsp. *palustris*, we would assume this taxon probably had a wide range in northern North America and eventually even found its way to Europe. The ice obliterated this earlier distribution in North America. One element survived in the Rocky Mountains. After the ice retreated, this element (var. *palustris*) then spread to eastern Canada and northeastern United States, but probably no farther south than New York. Another element survived in unglaciated Alaska. After the ice retreated, this element (var. *williamsii*) moved onto the glaciated area in northern Alaska, Yukon, and east to Churchill, Manitoba. Hultén included var. *williamsii* (*Nasturtium williamsii*) in a group of Northern Beringia radiants. He wrote that practically all species of this group are confined to Alaska and are only slightly differentiated. These are doubtless young species and must be expected to have become differentiated from isolated partial areas of widespread species, probably during the last interglacial (p. 54). We may then suspect that subsp. *palustris* was more uniform morphologically when it was widespread, but since it was split by the glacier, slight changes have occurred. Because var. *palustris* is in both Europe and America, it has the widest range, and has probably existed longer—it may represent the basic kind. The var. *williamsii*, being the younger, may have undergone slight morphological changes, and such differences are shown in the leaf and silique apices—characters now making this distinct from var.

palustris. Plants intermediate between the two varieties, to be expected in northern Canada, are not yet known.

Previously I mentioned that var. *cernua* probably spread onto the Alaskan coast from the Rocky Mountain center of diversity because plants are found in the latter area that are morphologically intermediate between it and var. *glabrata*. This migration has been implied as shown in map 20-W. I also pointed out that there is evidence for a center of diversity in Alaska. In the Aleutian Islands and the Alaskan Peninsula, one of Hultén's refugia [survivia], plants of *R. palustris* are found with nearly all the character combinations known for the Alaskan plants. Thus, it may have been from this subcenter that var. *clavata* and both the short- and elongate-cylindrical fruited members of var. *elongata* in Alaska radiated. I also commented that var. *occidentalis* in Alaska is morphologically somewhat different from the conterminous United States plants. Perhaps these represent segregates that, once connected with the Rocky Mountain center of diversity, were cut off by glaciation and have since further diverged morphologically. One major problem is that I saw virtually no material from British Columbia and thus do not know the situation today in that important region. The taxonomy and probable history of *R. palustris* in British Columbia, Alaska, and Asia definitely need further study.

Hultén (1937, p. 47) has further remarked that:

> The splitting up of the earlier areas by ice . . . must have had a very important influence on the number and character of the biotypes [segregates] remaining within the different elementary areas [survivia] . . . It is evident that the selection of biotypes within the northern elementary areas [e.g., Alaska] must be different from that within the southern [e.g., Rocky Mountains]. When the ice recedes and the plants start to migrate from the isolated spots where they were left, the populations in the different elementary areas must differ in their composition. At any rate those to the north must differ considerably from the original populations which had occupied the same stations during the preceding interglacial. In other words: different races [segregates] of the species must have been formed under the influence of the ice. As long as those races are separated from one another geographically they may possibly be distinguishable, but when the migration has proceeded so far that the radiants from two elementary areas meet, hybridization and thereby an intergradation of the differences must be expected to occur. It is presumed that plant populations from different parts of the old area, isolated in Asia and in America by the extermination of the northern part of their distributional arc, will not be exactly alike in biotypes and variation.

This statement very well summarizes the distributional phenomenon that has occurred in northern *R. palustris* since Wisconsin glaciation, and thereby provides some explanation for the numerous segregates in this species complex.

Examination of the maps of *R. palustris* reveals that outside the Rocky Mountain center of diversity, no more than two subspecies share the same area, except in eastern North America where subspecies *hispida*, *glabra*, and *palustris* occur. This situation can be explained in part by the fact that in coastal eastern United States (at least south of New York), var. *palustris* is believed introduced from Europe. In certain North American areas where each subspecies grows by itself, each is distinct and the characters distinguishing it are best defined (e.g., an unexpanded stigma in var. *hispida* is best developed in the Rocky Mountains of Colorado and New Mexico; an expanded stigma in var. *fernaldiana*, south of the southern limit of Wisconsin glaciation). Further, each variety of any particular subspecies also grows by itself (except that some varieties west of the Continental Divide may not grow alone). However, mountains and river valleys are quite numerous, and therefore more isolation of a local nature can be found. For example, comparison of map 15 with map 17 suggests that var. *elongata* may grow with var. *clavata*. Yet var. *elongata* is more coastal in distribution and has never been found along the Columbia River where var. *clavata* is well developed. The range of var. *palustris* overlaps that of other varieties in North America, but this variety grows by itself in Europe. Where ranges of two varieties of a subspecies meet, there are plants morphologically intermediate between the varieties. A good example of this phenomenon occurs in the St. Lawrence River valley, where plants are transitional between var. *fernaldiana* and var. *glabrata* of subsp. *glabra*, but plants that are pure var. *fernaldiana* or pure var. *glabrata* are not known to me from that area. Similarly, specimens from coastal California somewhat combine characters of var. *occidentalis* and var. *clavata*, although I included them under var. *occidentalis*. In these situations there appears to be considerable gene flow among plants of varieties within the subspecies.

A more rigorous genetic barrier seems to exist between subspecies. Only where plants of two different subspecies grow together are there found hybrids. I have shown that var. *hispida* of subsp. *hispida* can be hybridized with var. *fernaldiana* of subsp. *glabra* to produce a plant combining the characters of these subspecies. Herbarium specimens having characters of both subspecies have been collected only where the subspecies grow together. Plants combining the characters of subsp. *hispida* var. *hispida* and subsp. *palustris* var. *palustris* have been found where the ranges of these subspecies overlap. Because of the complexity of *R. palustris*, I use the categories of both subspecies and variety. Therefore, based on present data, one of the major differences between a subspecies and a variety is that in a subspecies, hybridization may produce a plant with the distinguishing characters of both subspecies; whereas differences between varieties of a subspecies appear to be of a clinal or transitional nature. The geographical pattern of this species complex suggests that the taxonomic hierarchy has validity. Experimental work would be desirable.

21. RORIPPA BARBAREIFOLIA (A. P. DeCandolle) Kitagawa, Jour. Jap. Bot. 13: 137. 1937. [orthographic correction by Kitagawa, cf. Art. 73].

Camelina barbareaefolia A. P. DeCandolle, Syst. Nat. 2: 517. 1821. ("Hab[itat] in Sibiriae orientalis provinciâ prope Doroninsk (Vlassov). [Perennial] (v.s.sp. comm. à cl. Fischer.") Holotype: Doroninsk Vlass[ov], 1819, *Mr. Fischer s.n.*, G-DC. Microfiche 1:201.5, card no. 101, MICH!; Delessert, Ic. Sel. Pl. 2: t.70. 1823.)

Tetrapoma barbareaefolium (A. P. DeCandolle) Turczaninow ex Fischer et Meyer, Ind. Sem. Hort. Petrop. 1: 39. 1835; Linnaea Litt.—Ber. 10: 104. 1836; Turczaninow, Fl. Baicalensi-Dahurica 147. 1842; Bull. Soc. Nat. Mosc. 15: 265. 1842.

Tetrapoma kruhsianum Fischer et Meyer, Ind. Sem. Hort. Petrop. 1: 39. 1835; *Tetrapoma krusianum* [sic] Fischer et Meyer, Linnaea Litt.-Ber. 10: 104. 1836. ("Hab[itat] in Sibiria orientali prope Ischiginsk." Type not seen.)

Tetrapoma pyriforme Seemann, Bot. Voy. Herald 24, t.2. 1852. [New name proposed for *Camelina barbareaefolia* A. P. DeCandolle]

Cardamine palustris ("Leysser" [Linnaeus]) O. Kuntze ϵ *normalis* O. Kuntze 3. *barbareaefolia* (A. P. DeCandolle) O. Kuntze, Rev. Gen. 1: 25. 1891.

Nasturtium barbareaefolium ("Turczaninow" [A. P. DeCandolle]) Fedtschenko, Acta Horti Petrop. 31: 7, 142. 1912. Non Baker 1877. Non Franchet 1888.

Nasturtium hispidum (Desvaux) A. P. DeCandolle f. *tetrapoma* (Turczaninow ex Fischer et Meyer) N. Busch, Fl. Sib. et Orient. Extr. 15: 207. 1915.

Radicula barbaraefolia [sic] (A. P. DeCandolle) Wight ex P. S. Smith, U. S. Geol. Surv. Bull. 655: 44. 1917.

Rorippa barbareaefolia (A. P. DeCandolle) Porsild, Rhodora 41: 232. 1939. [Intended new combination antedated by Kitagawa (1937)]

Rorippa hispida (Desvaux) Britton var. *barbareaefolia* (A. P. DeCandolle) Hultén, Fl. Alaska & Yukon 5: (Lunds Univ. Arssk. II. Sect. 2. 41:) 829. 1945.

Winter annual; stems 3-7(9) dm. tall, erect, single or much branched from the base, densely villous below, moderately villous to glabrous above; basal and cauline leaves sessile, slightly to strongly auriculate, clasping to non-clasping, oblong, narrowly oblanceolate or lanceolate, 2.5-10(15) cm. long, 0.4-1.5(2) cm. wide, both surfaces densely to sparingly villous to hirsute, the margin entire, irregularly serrate, lacinate-divided or repand, tapering to cuneate at the base, the apex acute; racemes terminal and axillary, 1-2 dm. long, forming after stem elongation, the oldest siliques therefore on the lower portion of the terminal raceme; pedicels (5)8-13.5 mm. long, ascending, densely to sparingly hirsute or glabrous, ca. 1.5-3 times as long as the siliques; sepals ovate to oblong, 1.7-2.7 mm. long, 0.6-1.3 mm. wide, flat, caducous in fruit; petals obovate to broadly spatulate, 1.8-3.5 mm. long, 0.8-2 mm. wide, slightly shorter than, equal to, or slightly longer than the sepals; siliques globose, subglobose, or pyriform, (3.2)4-5.7 mm. long, (2.3)2.7-4.1 mm. wide, ca. 1-2 times as long as wide, the valves 4, rarely up to 6, smooth, glabrous; replum circular to elliptic in outline, the margin convex and glabrous; style 0.6-1.4 mm. long, thick, ca. 0.5-1 mm. wide in fruit, straight throughout, abruptly attached to the rounded silique apex; stigma unexpanded; seeds oblong, ca. 0.5-0.7 mm. long, ca. 60-80 per silique, dark reddish brown, finely reticulate-foveolate; flowering and fruiting June-August.

ILLUSTRATIONS: Anderson (1959, p. 275, fig. 537), silique; Busch 1915, p. 208), as *N. hispidum* f. *tetrapoma*; Delessert (Ic. Sel. Pl. 2: t. 70. 1823); Fernald (1940, opposite p. 261, pl. 605, fig. 9), photograph; Seemann (1852, pl. 2), as *T. pyriforme*.

Rorippa barbareifolia is unique in having short, globose to pyriform, 4-valved, but sometimes 3-6-parted, siliques dehiscent at the apex. The anthers, unlike those in other species of section *Rorippa*, are elongate (3 times as long as wide), much like those of *Sinuatae*. The trichomes are usually extremely numerous on the stem, which is quite villous below. A short, thick style with an unexpanded stigma and quite long, stout, ascending pedicels are further distinctions. Specimens from the eastern Pacific coast of Alaska at Yes Bay (*Gorman 169*, US; *202*, ND-G 5139, NY, US; *Howell 1607*, MO, ND-G 5138, NY, US) and from Deer Mountain, Ketchikan (*Walker 985*, NY, US) approach *R. barbareifolia* very closely in having nearly all siliques 4-parted; however the fruits are mostly elongate-cylindrical, mostly over 6 mm. long, and the stem trichomes are very sparse. These plants have been referred to and mapped as R. *palustris* subsp. *hispida* var. *elongata*. Some fruits on specimens of var. *elongata* from the Pacific coast states of the United States are 4-valved, and in each variety of the *R. palustris* complex, occasional siliques not bivalved can be found. These occur most frequently in *R. palustris* subsp. *hispida* and subsp. *occidentalis*, rarely in subsp. *glabra* and subsp. *palustris*. In specimens of var. *elongata* from central Alaska, where *R. barbareifolia* grows, non-bivalved siliques do not occur. There appears to be no intergradation of *R. barbareifolia* with the varieties of *R. palustris* in that region. Morphologically, *R. barbareifolia* is most closely related to var. *elongata*, and it probably arose out of the variable *R. palustris* complex of the Pacific northwest of the United States via var. *elongata*.

On the basis of the globose fruits, DeCandolle (1821) first described this species in *Camelina*, but Fischer and Meyer (1835) transferred it to their new genus *Tetrapoma* because of the 4-valved siliques. Seemann (1852) could find no differences in fruit shape and style length among the plants; he further confused the situation by providing an unnecessary new name. More recently Hultén (1945) treated it as a variety of *R. hispida*, suggesting close alliance with the *R. palustris* complex.

Several *nomina nuda* have been published. They are as follows: (1). *Tetracellion ellipsoideum* Hort. Turczaninow ex Fischer et Meyer, Ind. Sem.

Hort. Petrop. 1: 39. 1835, pro syn. under *Tetrapoma barbareafolium* (A. P. DeCandolle) Turczaninow ex Fischer et Meyer. ("Hab[itat] in Dahuria."); (2). *Tetracellion ellipsoideum* Turczaninow *pl. exs. 1832.* in Flora Baicalensi-Dahurica 147. 1842; Bull. Soc. Nat. Mosc. 15: 265. 1842, both pro syn. under *Tetrapoma barbareaefolium* (A. P. DeCandolle) Turczaninow ex Fischer et Meyer; (3). *Tetracellium ellipsoideum* (Turczaninow) Steudel, Nom. Bot. 2: 669. 1841. [Steudel changed the spelling of *Tetracellion* to *Tetracellium.*]; (4). *Tetrapoma crusianum* ("Turczaninow" [Fischer et Meyer]) Walpers, Rep. 1: 154. 1842. [Walpers changed the spelling of the epithet *kruhsianum.*]; (5). *Tetrapoma sphaeroideum* Turczaninow *exs. 1834.* in N. Busch, Fl. Sib. et Orient. Extr. 15: 207. 1915. nom. nud., pro. syn.

DISTRIBUTION: Map 19. SIBERIA: Busch (1915, p. 209), as *N. hispidum* f. *tetrapoma.*

In North America, *R. barbareifolia* is virtually confined to central unglaciated Alaska. Seemann (1852) wrote: "The native country of the plant I believe to be Northern Asia. It has been found between Aldan and Ochotsk (*Turczaninow*), at Isinga, at Koragisk, and by me in Norton Sound [Alaska], where I have reason to believe it has been brought by the Russians, but where it is now perfectly wild." Rothrock (1868) agreed, on the basis that the plant had not been found elsewhere in North America; and so did Turner (1886), who copied from Rothrock.

Rorippa barbareifolia grows in alluvial sandy clay soil at recently disturbed sites along roadsides, burned-over spruce woods, gravel pits, and around dumps—habitats often harboring weedy plants introduced from other regions. However, I find a specimen collected in interior Alaska at Fort Youcon [sic] in 1866 by Ketchum (*s.n.*, NY). Although Fort Yukon was an important early trading center, it seems unlikely that a plant of Asia would have been introduced to interior Alaska at such an early date.

The reports of this species being introduced were written when central Alaska was virtually botanically unknown. With more collections available, with a distribution pattern that correlates with glaciation, and with a close morphological relationship to the North American *R. palustris* complex, *R. barbareifolia* certainly seems indigenous to Alaska.

Porsild (1939, p. 233) pointed out that *R. barbareifolia* forms an abundance of small light seed suitable for wind dispersal. The seeds germinate primarily on fresh mining dumps where there is no competition with the weedy perennials that in several years succeed *R. barbareifolia.* Further, he pointed out that *R. barbareifolia* "is not uncommon in suitable places in the Norton Sd. and Kotzebue Sd. regions, far from past and present human habitation. While it might perhaps have been introduced at St. Michaels, the species, no doubt, is indigenous to Alaska."

With respect to its possible relationship to glaciation, we can say that if *R. barbareifolia* were common elsewhere in areas where collectors have been (especially along the coast) it would likely have been found by now. Therefore, it must be absent (or very rare) on glaciated territory. Porsild (1951), who did extensive field work in southeastern Yukon, did not see specimens of this taxon. If we compare the distribution of *R. barbareifolia* in Siberia (Busch, 1915) with a map showing the glacial boundary in Siberia (Hultén, 1937), we find that *R. barbareifolia* in Siberia is also virtually confined to unglaciated territory except where it has apparently migrated northward along rivers into the glaciated region.

Three collections of *R. barbareifolia* need some comment. (1) The specimen from British Columbia (*Shetler & Stone 3054*, MICH) is clearly out of range. It was collected in the vicinity of the Alaska Highway, perhaps introduced there in recent years. (2) C. L. York's collection (*389*) at MO is labeled as coming from the Anchorage area. I did not map this locality because of the questionable label data. York used a printed label "Plants of the Anchorage Area," and his specimen of *R. palustris* subsp. *hispida* var. *elongata* (MO) has the typewritten datum "McKinley National Park." Since McKinley Park is some 150 miles north of Anchorage, there is contradiction here. His specimen of *R. barbareifolia*, a species known to grow in the McKinley Park area, contains no additional locality data. With this brief evidence, there seems to be a possibility of mixed labels or specimens. (3) Hultén (1945, p. 829) reports a collection from "Valdez Puer 7550a (H)," a locality along the central Pacific Alaskan coast on glaciated territory. It seems doubtful that he would have misidentified the plant.

With ever increasing settlement in Alaska, there have been more road building and mining and more soil disturbance, resulting in more habitats for *R. barbareifolia*. Thus *R. barbareifolia* may now be more common in central Alaska than 100 years ago; it may be spreading into disturbed sites in unglaciated areas (it has been found at Wiseman, Cantwell, and McKinley Park, which are near the unglaciated areas; and it may even be spreading into areas still farther removed from central Alaska, such as along the Alaska Highway.

Data suggest that *R. barbareifolia* arose out of the variable *R. palustris* complex of northwestern United States before glaciation, was cut off from these prototypes by the Cordilleran ice sheet of British Columbia, and survived and became morphologically distinct on unglaciated territory in central Alaska and Asia.

Summary of Section Rorippa. There are at least three lines of evolutionary development in native North American species of section *Rorippa*, based primarily on how the style is attached to the fruit.

One group has a style that gradually merges into the silique and is either straight throughout or tapers to the apex. The stigma is unexpanded. *Rorippa curvisiliqua*, *R. tenerrima*, and *R. microtitis* belong here (fig. 8-B 2, 3). In this character, the group is most closely allied to the long-fruited members of *Sinuatae*.

In a second group, the style gradually merges into the silique but instead of being straight or tapering, it expands below the stigma; the stigma itself may be expanded or unexpanded (fig. 8-B 1). The style, often quite thick, is extremely short in the most highly evolved members of this alliance. In this group there is also the development of numerous, small, pitted to nearly smooth seeds and a tendency toward reduction or absence of petals. The southeastern *R. sessiliflora*, *R. portoricensis*, and *R. teres*, as well as *R. mexicana* of the Central American and Mexican uplands, belong here.

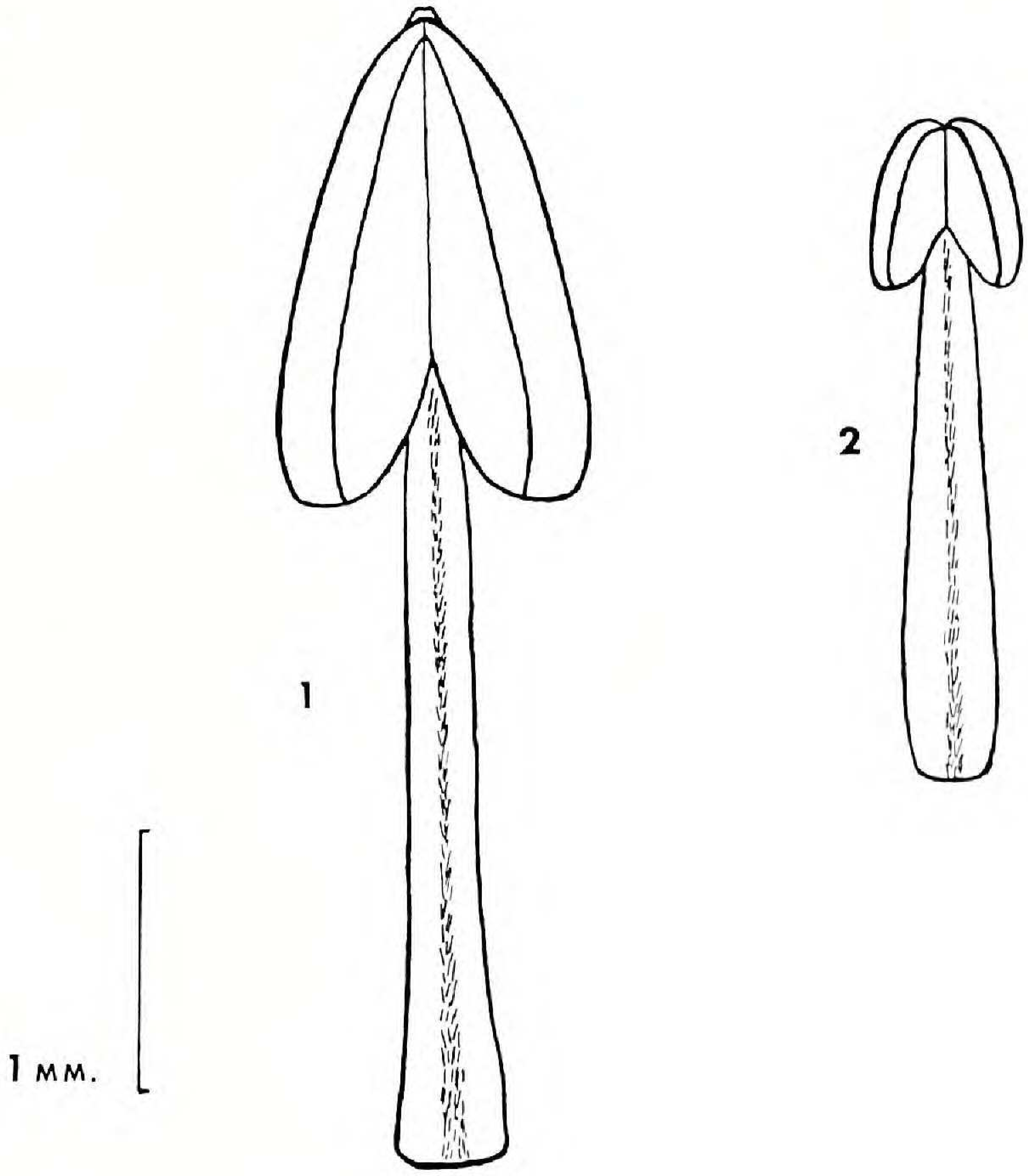
A third group is of plants whose styles are usually slender and attached to the obtuse or truncate silique. This character is best developed in *R. truncata* (fig. 8-B, 4). In *R. pinnata* and in certain segregates of *R. curvipes* with a pointed silique apex, it is difficult to assess the character. The stigma may be expanded or unexpanded. Included in this group are the pinnate-leaved members from Mexico and Central America, the *R. curvipes* complex, *R. palustris*, and *R. barbareifolia*. In the latter, the style is thick, however.

This section contains the young, rapidly evolving species of North American *Rorippa*. These have a number of morphological variations which have segregated geographically but have not progressed far enough to be considered Linnaean species. Members of this section often have characters considered derived (advanced), such as annual habit, plants growing singly from taproots, petals usually shorter than the sepals, short anthers notched at the apex, short styles, and usually numerous, small, mostly minutely colliculate to foveolate seeds. There is considerable fluctuation in some of these characters in section *Rorippa*.

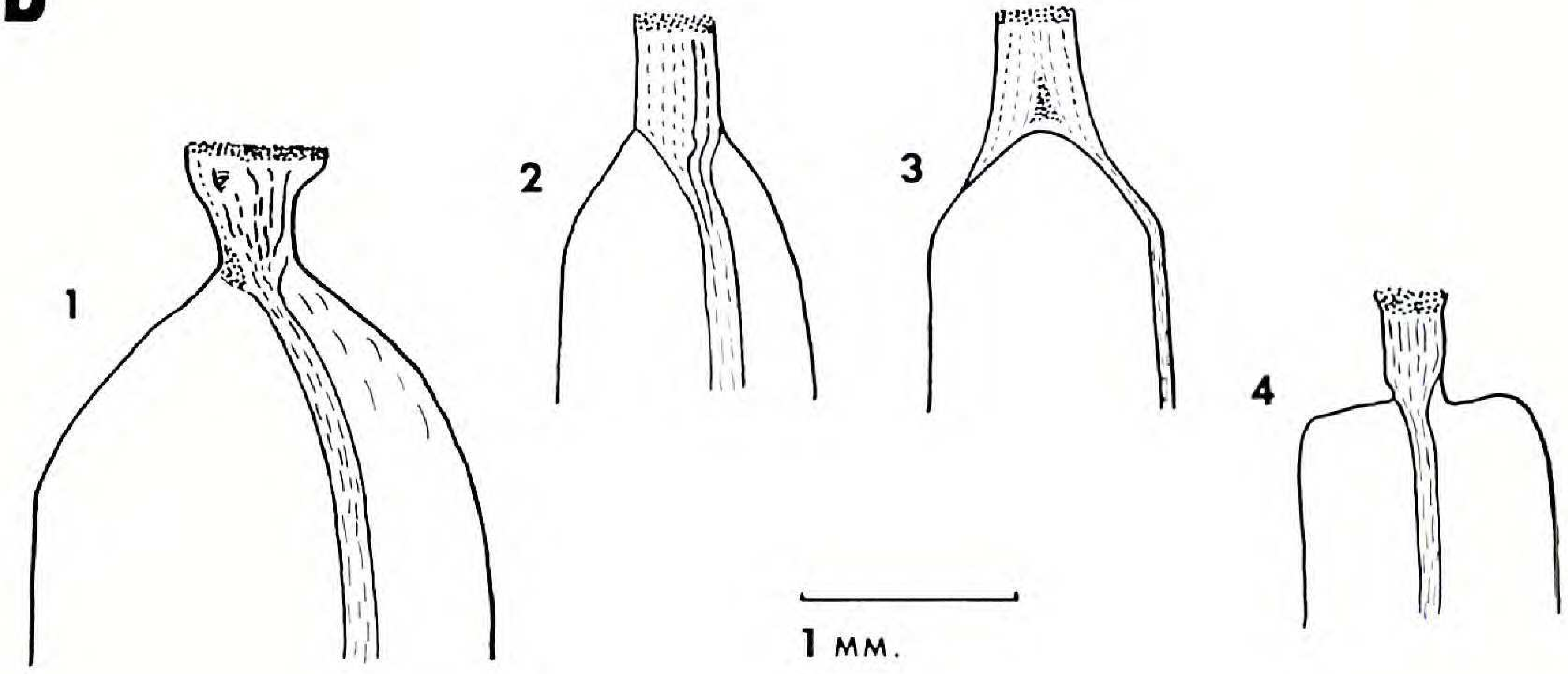
These annuals with taproots, basal rosettes, and thin leaves are apparently less adapted to dry regions for they are essentially absent from the Great Plains where clonal *R. sinuata* (section *Sinuatae*) grows. The other species of *Sinuatae* also usually grow in dry places. Members of section *Rorippa* grow in wetter regions, such as eastern North America, the mountains of western United States, and the uplands and mountains of Mexico and Central America. In the discussion of the distribution of *R. sinuata* and in the summary of *Sinuatae*, some distribution patterns of species from section *Rorippa* are compared to those of *Sinuatae* in these ecological and distributional differences.

Fig. 8. Anther and Style Types in North American *Rorippa*. A. The two kinds of anthers: 1. Stamen with elongate anther, ca. 1.5-3 times as long as wide, apiculate; the primitive condition; section *Sinuatae; R. sinuata (Stuckey 1634*, MICH). 2. Stamen with short anther, ca. 1-1.5 times as long as wide, notched at the apex; the derived condition; section *Rorippa; R. palustris* subsp. *hispida (Stuckey 1772*, MICH). B. The three basic style types in section *Rorippa*: 1. Style expanded below the stigma; style gradually merging into the silique apex; ventral view; *R. sessiliflora (Stuckey 1604*, MICH). 2.-3. Style straight throughout; style gradually merging into the silique apex; *R. curvisiliqua* var. *lyrata (Stuckey 1927*, MICH). (The style may be tapering to the apex in this type.) 2.—ventral view, 3.—lateral view. 4. Style straight throughout; style abruptly attached to the silique apex; ventral view; *R. truncata (Stuckey 1968*, MICH).

A



B



SUMMARY OF GEOGRAPHICAL AND EVOLUTIONARY RELATIONSHIPS IN NORTH AMERICAN RORIPPA

Within a species or among a group of closely related species in *Rorippa* are often well-defined centers of morphological diversity, that is, areas where all or nearly all the morphological variations in a species complex occur. Among the annual species (section *Rorippa*), there are three well-defined centers of diversity in the Rocky Mountains of the United States: (1) eastern Washington and northern Idaho for *R. curvisiliqua*, (2) northern Idaho and western Montana for *R. palustris*, and (3) northern Utah for *R. curvipes*. They are bridged morphologically and geographically by *R. curvipes* var. *integra*. These areas are somewhat centrally located in the range of each respective species complex. From the centers radiate several morphological segregates that may or may not be isolated geographically. Where overlap occurs in ranges or flowering time, intermediates are found. These segregates are the young, rapidly evolving taxa, and their distribution appears to be influenced by current factors, e.g., the amount of rainfall.

Rorippa curvisiliqua (maps 5, 6, 20-G) appears to be the most recent to undergo this phenomenon: its center is well-defined and its segregates are geographically close together, often showing considerable overlap. The distinguishing characters of one segregate usually merge with those of one or more of the adjacent segregates. *Rorippa palustris* subsp. *glabra* (map 20-S to W) has a well-defined center, but the segregates are much farther apart geographically and therefore are well-defined morphologically in the area away from the center. The *R. curvipes* complex (map 20-P to R) combines features of both of the above patterns. In the case of *R. truncata*, (map 20-P) the pattern has gone one step further. Apparently its center has become obliterated, leaving the surviving population fragments in several of the major river valleys. If these isolated populations were to diverge in different directions morphologically, isolated species might form, creating a situation similar to that of the isolated, oblong-fruited members of *Sinuatae*. These few well-defined species, *R. calycina* (map 20-A), *R. columbiae* (map 20-B), and *R. subumbellata* (map 20-C), are geographically isolated along the Yellowstone River, on the Columbia River lava plateau, and at Lake Tahoe, respectively. These three species are believed to be old, relic species, and they probably represent the fragments of a former more widespread and variable complex, but the morphological intermediates of the center have since died out. Such old species in old areas show characters considered primitive: perennial habit, long petals longer than the sepals, long anthers with the connective remaining at the apex, long pedicels, long styles in fruit, and few big seeds. *Rorippa sinuata* (map 20-D), a species with these primitive characters, is linked morphologically to these old relics (*R. calycina*) via the unique but very rare *R. coloradensis*. If we follow the gradual morphological changes that occur in these characters (Table 2, and map 20), we find a series of plants beginning with *R. sinuata* (map 20-D) (longest petals, longer than the sepals) of western United States,

TABLE 2. EVOLUTIONARY TRENDS OF CERTAIN CHARACTERS IN SOME RELATED SPECIES OF RORIPPA, SUGGESTING THE DIRECTION OF THEIR APPARENT MIGRATION (SEE MAP 20).

Species	Petal Length	Anthers	Pedicel Length	Style Length	Seed Length	Approximate No. Seeds Per Silique
(D.) R. *sinuata* (w. United States)	longer than the sepals, 3.5-5.5 mm.	elongate, apiculate	longest, 5-11.5 mm.	longest, 1-2 mm.	longest, 0.7-0.9 mm.	40-80
(H.) R. *microtitis* (s.w. United States, n. Mexico)	longer than the sepals, 2.5-3.7 mm.	elongate, apiculate	fluctuating, 3.5-10.5 mm.	0.5-1 mm.	mature ones not known, ? 0.6-0.7 mm.	?
(I.) R. *mexicana* (n. Mexico to Costa Rica)	longer than the sepals, 1.7-2.6 mm.	transitional	2.4-5.4 mm.	0.5-1.2 mm.	0.7-0.8 mm.	70-100
(J.) R. *teres* (Coastal Plain)	mostly equal to or shorter than the sepals, 1-1.7 mm.	short, notched	2.5-4.5 mm.	0.5-1.5 mm.	0.4-0.5 mm.	100-150
(K.) R. *portoricensis* (West Indies)	shorter than the sepals, 0.8-1.2 mm., or absent	short, notched	1-2.2 mm.	0-0.5 mm.	0.4-0.6 mm.	50-100
(L.) R. *sessiliflora* (Mississippi embayment and s.e. United States)	absent	short, notched	shortest, 0.5-1.5 mm.	shortest, 0-0.4 mm.	shortest, 0.4-0.5 mm.	150-200

moving south to *R. microtitis* (map 20-H) (long petals, longer than the sepals), moving still farther south to *R. mexicana* (map 20-I) (shorter petals, but longer than the sepals) of the uplands of Mexico and Central America, *R. teres* (map 20-J) (short petals, mostly equal to or shorter than the sepals) of the Coastal Plain, and *R. portoricensis* (map 20-K) (petals shorter than the sepals or absent) of the West Indies, and finally culminating in the apetalous *R. sessiliflora* (map 20-L) of the lower Mississippi valley and southeastern United States. Table 2 gives trends of the six characters.

In a rather recent and rapidly evolving family such as Cruciferae, it is possible to find a few morphological characters that show evolutionary trends from a primitive to a derived state, and these can be correlated with geographical distribution which suggests the apparent migration. However, within or among the species that have centers of diversity, I cannot decide which characters are primitive and which derived. Characters appear to be changing in at least two directions. For example, both long petals (longer than the sepals) and short petals (shorter than the sepals) or both long and short pedicels occur in *R. curvipes* and *R. curvisiliqua*. Whereas the presence of numerous small seeds in *R. sessiliflora* is a derived condition in the evolutionary line described above, the few seeds in *R. intermedia* and the big seeds in *R. megasperma* are considered derived in the pinnate-leaved group which represents a different evolutionary line that probably arose out of the *R. curvipes* complex. Other examples could be cited. It is evident that no one character can be considered primitive throughout the genus.

Some characters fluctuate. One of these is recurved pedicels, which occur in at least one taxon within every species complex (except in *R. curvisiliqua*) or in one of a group of closely related species. Recurved pedicels occur in *R. calycina* of the relic group, in *R. mexicana* of the group whose styles are expanded below the stigma, in *R. pinnata* of the pinnate-leaved group, in *R. curvipes* var. *curvipes* and *R. sphaerocarpa* of the *R. curvipes* complex, and in *R. palustris* subsp. *glabra* var. *cernua*. A similar situation occurs in the character of raceme position (all lateral racemes and no terminal raceme) found in *R. calycina* (p.p.), *R. columbiae* (p.p.), *R. ramosa*, *R. mexicana*, *R. teres*, *R. tenerrima* (p.p.), *R. truncata*, and *R. sphaerocarpa* (p.p.) but not in *R. palustris* and *R. curvisiliqua*. Other characters behave similarly. With this kind of behavior in the genus, the determination of which characters are primitive and which are derived is difficult.

Geographical and evolutionary relationships are summarized in map 20. The black arrows connect the most closely related species, and the direction of the arrow indicates the most probable line of morphological divergence and direction of migration. At various places in the text intermediate plants between certain species were pointed out. In those cases the position of the arrow is the approximate area where those plants are found. To read the chart in its entirety, one should begin with taxon D, *R. sinuata*, a species with characters considered primitive. From it can be traced the apparent evolutionary and distributional history of North American *Rorippa*. *Rorippa* *ramosa* (map 20-E) and *R. tenerrima* (map 20-F) are offshoots which have not developed further and are therefore abruptly terminated lines of development.

The closest relative of any one species of *Rorippa* is a species that lies geographically next to it. For example, *R. curvisiliqua* is adjacent to *R. sinuata*, which is adjacent to *R. microtitis*, which is adjacent to both *R. curvisiliqua* and *R. mexicana*, and the latter is adjacent to *R. teres*. Payson (1921, p. 129) found a similar phenomenon in *Lesquerella*. The situation in both genera appears to exemplify Jordan's Law (Jordan, 1905). Seeing what a variable complex like *R. curvisiliqua* is doing today is helpful in explaining and understanding what has apparently happened in the past to bring about such a distribution pattern. Morphologically similar and related species are adjacent to each other geographically, but morphologically diverse and unrelated species are sympatric. Good examples are *R. megasperma* sympatric with *R. mexicana*, and *R. sessiliflora* sympatric with *R. palustris*. In North America outside the United States Rocky Mountains, usually no more than three species, representing three different evolutionary lines, are in the same region. These species, often found together, are apparently kept separate by strong barriers to interbreeding. The plants are self-fertile, one factor keeping them isolated. Other factors and the details of such isolating mechanisms are not known.

One interesting question arises. How old is *Rorippa?* With present knowledge we can look to four points in time as possible markers for working in the time sequence. *Rorippa columbiae* is considered a relic species with primitive characters. Its distribution appears to be correlated with a very old soil type, the Columbia River lava plateau of the Tertiary. If *R. columbiae* was a pioneer plant on these soils when or soon after they were formed, it appears that *Rorippa*, at least this species, was in existence during the latter part of the Tertiary.

If we accept that *R. teres* originated in the uplands of Mexico and then migrated onto the coastal plain at the end of the Tertiary or beginning of the Quaternary, we then have a second point in time. Trends in the characters presented above reveal that *R. teres* arose out of a line of development related to the old relics of *Sinuatae*. Thus we would expect *R. teres* to be younger than these relics.

Rorippa sessiliflora is more divergent from *R. teres* in its characters and probably arose from a common ancestor slightly later than *R. teres*. It then migrated north in the lower Mississippi valley. Since it appears from the distribution map of *R. sessiliflora* (map 9) that its northward migration was strongly influenced by Wisconsin glaciation (the third point in time) of the late Pleistocene, this migration probably occurred slightly later than that of *R. teres* onto the coastal plain.

Rorippa palustris is considered one of the younger species. According to Hultén (1937, p. 118-119), boreal circumpolar plants, including *R. palustris*, were either widespread in boreal regions before glaciation or arose during the interglacials. This, the fourth point in time, is also recent geologically.

It appears from these markers that the North American species of *Rorippa* are properly placed, not only as to evolutionary divergence and migration, but also as to time. In this scheme, the time relationship of *R. curvisiliqua* and the *R. curvipes* complex is obscure. The former is believed to be an old species, since it seems most closely allied (at least geographically) with *R. sinuata*, but its divergence into a number of morphological and geographically close segregates suggests a more recent event. The *R. curvipes* complex may be as old as or slightly younger than *R. curvisiliqua* but is probably older than *R. palustris*. Map 20 portrays this sequence. The fragmented circular range of *R. truncata* (map 11) with an empty center, and its close alliance with the pinnate-leaved group of Mexico and Central America suggest an old age, at least late Tertiary.

I know of no fossil evidence to document this probable history. However, Godwin (1956) reported that two late-glacial seeds in the Reid collection closely resemble seeds of *R. palustris*.

APPENDIX I. THE PROBLEM OF RORIPPA CRYSTALLINA

22. RORIPPA CRYSTALLINA Rollins, Rhodora 64: 326. 1962. (Holotype: CANADA: MACKENZIE: Carex marsh with drying areas more or less bare of vegetation, Mile 23 N., Yellowknife Highway along the Mackenzie River, 10 Jul 1961, *J. W. Thieret, R. J. Reich 7512*, GH!)

Since no new data on *R. crystallina* are available, the reader is referred to Rollins (1962). I studied the same material that Rollins cited. He pointed out certain difficulties with regard to the genus to which this species belonged and finally concluded that it had more in common with *Rorippa*, even though no single species of *Rorippa* could readily be singled out for comparison. His decision to put it in *Rorippa* is justified, but I can not relate *R. crystallina* to any native North American species of the genus. Although a detailed search has not been made for calcium oxylate crystals, an important feature of this species, pustules formed by these crystals on leaves have not come to my attention in other North American species. The seeds of *R. crystallina* are extremely plump and broadly oblong and are much larger (1.5-2 mm. long) than in our native species. The finely reticulate-colliculate, buff colored seed coat with a mucilaginous sheath is also not found in North American *Rorippa*. Large white petals sometimes tinged below with light lavender are also different.

Rorippa crystallina has a morphological relationship to *Nasturtium barbareaefolium* Franchet (Bull. Bot. Soc. Fr. 33: 396. 1888.) of China. (The name *N. barbareaefolium* Franchet is actually an illegitimate later homonym of *Nasturtium barbareaefolium* Baker (Fl. Mauritius & Seychelles. 7. 1877.) Neither of these epithets can be transferred to *Rorippa* because of the existence of *R. barbareifolia* (A. P. DeCandolle) Kitagawa.) I examined two collections of this species: YUN-NAN: *Delavay 1840* (GH); and SZECHWAN: *Fang 4483* (GH). The former collection, cited by Franchet, is an isosyntype. Both species are very similar in overall appearance and in the shape of siliques and seeds. The leaves of the Asiatic plant sparingly bear pustules apparently of calcium oxylate. *Nasturtium barbareaefolium* differs from *R. crystallina* in having shorter (5-8 mm. long) pedicels, ascending to appressed pedicels and siliques, and sparingly to moderately hirsute leaf surfaces and stem. Thus, *R. crystallina* is related to Asiatic members of the genus, not North American ones. Perhaps the differences from the North American taxa would be sufficient to form a section within the genus based on the pustulate leaf condition and on differences in seeds and petals. Asiatic members of the genus are in need of study.

Phytogeographically, does *R. crystallina* represent the end of an evolutionary migrational line that existed across eastern Siberia, Alaska, and into Canada? Or has *R. crystallina* been introduced into North America?

APPENDIX II. SPECIES INTRODUCED INTO NORTH AMERICA

Seven species of *Rorippa* are considered introduced into North America. Their distributions, highly irregular and sporadic, do not correlate with natural physiographic or glacial features, as do those of native taxa. If there is doubt whether a particular species that grows in a large area (e.g., a continent) is native or introduced, the determination of its total range throughout the area in question may answer this question. The distribution of a native species should correlate with some natural feature such as glaciation, climate, soil, rainfall, rivers, mountains, deserts, etc.; whereas the introduced one will probably not show a correlation. Other criteria, such as actual date of introduction, historical records, field observations, morphological relationships, etc., are highly desirable. If the above idea has validity, then we may have another argument for believing that *R. barbareifolia* is native to Alaska and Yukon: it shows a relationship to glaciation not only there but throughout its range.

In interpreting the introduced species from Europe, I have followed Wannenmacher (1960). Selected references to descriptions, illustrations, and distribution maps are given for each introduced species. Only a few selected synonyms have been cited.

23. RORIPPA SYLVESTRIS (Linnaeus) Besser, Enum. Pl. Volh. 27. 1822.

Sisymbrium sylvestre Linnaeus, Sp. Pl. 657. 1753.

Nasturtium sylvestre (Linnaeus) R. Brown in Aiton, Hort. Kew. ed. 4: 110. 1812.

Radicula sylvestris (Linnaeus) Druce, List Brit. Plants 4. 1908.

DESCRIPTIONS: Butcher (1961, p. 335); Clapham, Tutin, & Warburg (1962, p. 174); Jonsell (1968, p. 160); Valentine (1964, p. 283); Wannenmacher (1960, p. 177).

ILLUSTRATIONS: Britton & Brown (1897, p. 124, fig. 1713; 1913, p. 160, fig. 2026); Butcher (1961, p. 335); Clapham, Tutin, & Warburg (1962, p. 173, fig. 23, A), silique; Fassett (1940, p. 232, fig. 19); Gleason (1952, p. 239); Groh (1936, p. 33, fig. 1, A-D), taken from Muenscher (1942); Hitchcock & Cronquist (1964, p. 540); Jonsell (1968, plates IX-XI, photographs of plants; Marie-Victorin (1947, p. 264); Muenscher (1942, p. 272, fig. 50, A-D); Murley (1951, p. 72, fig. 21), seed; Musil (1963, pl. 32, fig. 255), seed; Steyermark

(1963, p. 759, pl. 185, no. 1); Wannenmacher (1960, opposite p. 169, Tafel 129, 5-5a, p. 179, fig. 94, e-g; p. 180, fig. 95, a).

DISTRIBUTION: NORTH AMERICA: Map 21; Stuckey (1966b, p. 364). NORTHWESTERN EUROPE: Hultén (1950, p. 238, fig. 927); Jonsell (1968, p. 99, fig. 13).

Rorippa sylvestris, creeping yellow cress, has been confused with several of the native North American species, in particular with *R. sinuata*, *R. palustris*, *R. teres*, and *R. microtitis*. The following single-couplet keys distinguish *R. sylvestris* from these species.

Key A

1. Plants glabrous or sparingly hirsute on the lower portion of the stem; leaves deeply divided, more than 2 cm. wide; basal rosettes present in young plants; style in fruit shorter than 1 mm. . . . . . *R. sylvestris*
1. Plants pubescent only with vesicular trichomes on the stem and lower surface of the leaves; leaves sinuate-lobed, less than 2 cm. wide; basal rosettes absent even in young plants; style in fruit longer than 1 mm. . . . . *R. sinuata*

Key B

1. Petals over 3 mm. in length, longer than the sepals; plants clonal from spreading roots and stems; pedicels longer than 5 mm.; racemes terminal and lateral; plants glabrous or sparingly hirsute on the lower portion of the stem. *R. sylvestris*
1. Petals under 2 mm. in length, equal to or shorter than the sepals; plants solitary from a slender taproot; pedicels shorter than 5 mm.; racemes all lateral; plants pubescent only with vesicular trichomes on the lower portion of the stem and on the upper surface of the basal and lower cauline leaves. *R. teres*

Key C

1. Mature siliques usually lacking seeds; plants clonal from slender spreading roots and stems; petals over 3 mm. in length, longer than the sepals. . . . . *R. sylvestris*
1. Mature siliques with seeds; plants solitary from a vertical taproot; petals under 3 mm. long, mostly equal to or shorter than the sepals. . . . . *R. palustris*

Key D

1. Mature siliques usually lacking seeds; plants clonal from slender spreading roots and stems. . . . . *R. sylvestris*
1. Mature siliques with seeds; plants solitary from a vertical taproot. . . . . *R. microtitis*

I found no evidence that *R. sylvestris* hybridizes with native North American species, although Jonsell (1968, p. 136-138) reports the occurrence of hybrids and gives a short description (p. 160).

Rorippa sylvestris, introduced into North America from Europe, is quite common east of the Mississippi River in northeastern United States and southern Canada, where it grows along streams, rivers, and ditches, about ponds and dumps, and in gardens. For a history of its distribution and migration in North America, see Stuckey (1966b).

24. RORIPPA AUSTRIACA (Crantz) Besser, Enum. Pl. Volh. 103. 1822.
Nasturtium austriacum Crantz, Strip. Austr. ed. 1. 15. 1762.
Radicula austriaca (Crantz) Small, Torreya 23: 23. 1923.

DESCRIPTIONS: Butcher (1961, p. 338); Clapham, Tutin, & Warburg (1962, p. 174); Jonsell (1968, p. 163-164); Valentine (1964, p. 283); Wannenmacher (1960, p. 176).

ILLUSTRATIONS: Butcher (1961, p. 338); Clapham, Tutin, & Warburg (1962, p. 173, fig. 23, D), silique; Gleason (1952, p. 239); Groh (1936, p. 333, fig. 1, J-L), taken from Muenscher (1942); Hansen (1922, p. 76); Jensen (1955, p. 69); Marie-Victorin (1947, p. 264); Muenscher (1942, p. 272, fig. 50, J-L); Murley (1951, p. 72, fig. 23), seed; Musil (1963, pl. 32, fig. 254), seed; Wannenmacher (1960, p. 176, fig. 93, a-d).

DISTRIBUTION: NORTH AMERICA: Map 22.

Rorippa austriaca, field cress, comes from Europe and was first reported in North America by Hansen (1922), who observed it at Borderland Farm, New Milford, Orange County, New York. According to the proprietor of the farm, the field cress was introduced about 1910 in grass seed. At first the plant occurred merely as a small patch not spreading to any extent for a number of years. By the time Hansen observed it in June 1921, about 5 acres were infested; patches of the plant occurred 200-300 yards from the main area; and roadsides about the farm were infested.

Small (1923) reported *R. austriaca* from Wisconsin on the basis of specimens sent to New York Botanical Garden in 1918. The plants, obnoxious on one of the University of Wisconsin fields, were thought to have been introduced in alfalfa seed from Turkestan.

Like *R. sylvestris*, *R. austriaca* often fails to produce seed but propagates by creeping roots. These roots, much thicker and more fleshy than those of *R. sylvestris*, resemble those of the horseradish, *Armoracia rusticana*. Plants with such root systems are ideally adapted for spreading into areas, especially cultivated areas, where competition is minimal. Hansen (1922), Small (1923), Groh (1933), and Jensen (1955) expressed concern that this species would become well established and more widespread and thus difficult to eradicate. However, since its introduction 50 years ago, it has apparently neither spread nor become obnoxious. Map 22 shows field cress in scattered isolated localities in North America. Each locality probably represents a separate introduction, except possibly in North Dakota where there may have been some spread through agricultural practices. *Rorippa austriaca* may occur more frequently than the map indicates, but supporting records are lacking. Whether it is currently being introduced or whether it is spreading from already existing populations should be investigated.

25. RORIPPA AMPHIBIA (Linnaeus) Besser, Enum. Pl. Volh. 27. 1822.
Sisymbrium amphibium Linnaeus, Sp. Pl. 657. 1753.
Nasturtium amphibium R. Brown in Aiton, Hort. Kew. ed. 2. 4: 110. 1812.

DESCRIPTIONS: Butcher (1961, p. 337); Clapham, Tutin, & Warburg (1962, p. 174); Jonsell (1968, p. 161-162); Valentine (1964, p. 283); Wannenmacher (1960, p. 180).

ILLUSTRATIONS: Busch (1915, p. 216); Butcher (1961, p. 337); Clapham, Tutin, & Warburg (1962, p. 173, fig. 23, C), silique; Fassett (1940, p. 232, fig. 17, 18), silique; Gleason (1952, p. 239); Marie-Victorin (1947, p. 264); Wannenmacher (1960, p. 176, fig. 93, e-g; p. 180, fig. 95, c).

DISTRIBUTION: NORTH AMERICA: Map 22. EURASIA: Busch (1915, p. 218); NORTHWESTERN EUROPE: Hultén (1950, p. 237, fig. 924); Jonsell (1968, p. 104, fig. 14).

Rorippa amphibia, introduced from Eurasia, was first correctly reported in North America from the St. Lawrence River (Marie-Victorin, 1930). When the introduction was made is not known. According to Marie-Victorin the species had become very aggressive and had spread at the expense of other, native hydrophytes. The report by Norton (1933) from Maine is correct. Although I have not seen a specimen on which Bradley (1931) based his report of *R. amphibia* from Ridgefield, Connecticut, his plants may belong to *R. prostrata*, since Eames collected plants in that town very similar to *R. amphibia* but which I placed in *R. prostrata*. The report from Iowa by Wolden (1956) was based on a specimen of *R. austriaca*.

26. RORIPPA PROSTRATA (Bergeret) Schinz et Thellung, Viertelj. Naturf. Ges. Zürich 58: 62. 1913.
Myagrum prostratum Bergeret, Phyton 3: 149. 1784.

DESCRIPTIONS: Valentine (1964, p. 283); Wannenmacher (1960, p. 178).

ILLUSTRATION: Wannenmacher (1960, p. 179, fig. 94, a-d).

DISTRIBUTION: NORTH AMERICA: Map 22.

According to Valentine (1964), *R. prostrata*, a European species, comprises a series of variants ranging from those near *R. amphibia* at one end to those near *R. sylvestris* at the other. It is generally considered of hybrid origin, although it sometimes occurs in the absence of one of the parents. Jonsell (in litt., 5 Oct 1964) writes that *R. prostrata* "seems to be a name for various more or less stabilized hybrid complexes of different origin." Plants from Pennsylvania and New Jersey match well the illustration in Wannenmacher (1960) and are close to *R. sylvestris* in silique length and leaf dissection. In Connecticut and New York, the plants approach *R. amphibia* in leaf and silique morphology. Thus our few specimens, too, are a series of variants between *R. sylvestris* and *R. amphibia*.

27. RORIPPA MICROSPERMA (A. P. DeCandolle) L. H. Bailey, Gent. Herb. 1: 25. 1920.
Nasturtium microsperma A. P. DeCandolle, Syst. Nat. 2: 199. 1825.

DESCRIPTION: Busch (1915, p. 211).

ILLUSTRATION: Busch (1915, p. 212).

DISTRIBUTION: ASIA: Busch (1915, p. 213).

Rorippa microsperma has the pedicels subtended by entire to pinnatifid leafy bracts and thus readily can be separated from all other *Rorippa* in North America. Our collection matches material from Asia (GH) annotated by A. N. Steward as *R. microsperma.* In North America *R. microsperma* is known from only one locality (Vancouver Island) where it undoubtedly was brought from Asia: BRITISH COLUMBIA: Ballast, vicinity of Nanaimo, 12 Jul 1893, *Macoun s.n.* (GH, ND-G, NY).

28. RORIPPA HETEROPHYLLA (Blume) Williams, Fl. Trinidad and Tobago 1: 24. 1929.

Nasturtium heterophyllum Blume, Bijdr. Fl. Nederl. Ind. II St. 50. 1825.

DESCRIPTIONS: Gleason (1952, p. 240); Schulz (1903, p. 517).

ILLUSTRATION: Gleason (1952, p. 241).

DISTRIBUTION: NORTH AMERICA: Map 22.

Rorippa heterophylla appears to be introduced from South America. North American plants have sometimes been referred to *R. indica.* Small (1913, p. 1336) reported plants of this species under the name of *R. montana.* Later (1933) he used the name *R. heterophylla.* Following Schulz (1903), I have included as *R. heterophylla* all of these apetalous plants having straight siliques with flattened, somewhat elastic valves and seeds in a single row in each locule. In the silique character, this species suggests *Cardamine,* but the leaves are much like those of *Rorippa.* Plants similar to *R. heterophylla,* but with curved siliques and petals longer than the sepals, are referred by me to *R. indica.* Some descriptions of *R. indica (e.g.,* DeCandolle, 2: 199. Syst. Nat. 1821) state that petals are absent. These taxa need clarification. Rollins (1969) considered these apetalous plants to be *R. indica* (Linnaeus) Hiern var. *apetala* (A. P. DeCandolle) Hochreutiner.

29. RORIPPA INDICA (Linnaeus) L. H. Bailey, Rhodora 18: 155. 1916.

Sisymbrium indicum Linnaeus, Mant. 93. 1767.

Nasturtium indicum (Linnaeus) A. P. DeCandolle, Syst. Nat. 2: 199. 1821.

Rorippa indica has been brought to North America from Asia where it has either been cultivated or has escaped from cultivation. ILLINOIS: [Cook Co.]: Cult[ivated], Lincoln Park, Chicago, 17 Jun 1898, *Umbach sn.* (WIS 8683); NEW YORK: Bronx Co. Weed under rhododendrons, New York Botanical Garden, Bronx Park, 2 Jun 1947, *18653,* weed in roadways and waste ground under rhododendrons, same locality, 28 May 1948, *19437,* both *H. N. Moldenke* (NY). Reported from the same locality by Monachino (1957). See the note under *R. heterophylla.*

REFERENCES

For references given in discussions of nomenclature consult the synonymy given for the taxon.

ABRAMS, L. 1944. Illustrated flora of the Pacific states. Vol. II. Stanford Univ. Press, Stanford. 635 p.

ANDERSON, J. P. 1959. Flora of Alaska and adjacent parts of Canada. Iowa St. Univ. Press, Ames. 543 p. (Reprinted from a series of papers published in the Iowa St. Coll. Jour. Sci. from the years 1943-1952.)

BELLUE, M. K. 1933. Austrian field cress—new and noxious. Mon. Bull. Dep. Agr. Calif. 22: 385-386.

BRADLEY, L. J. 1931. *Rorippa amphibia* in Fairfield County, Connecticut. Rhodora 33: 192-193.

BREITUNG, A. J. 1957. Annotated catalogue of the vascular flora of Saskatchewan. Am. Midl. Nat. 58: 1-72.

BRITTON, N. L. 1891. New and noteworthy North American phanerogams.—IV. Bull. Torrey Club 18: 265-272.

———. 1901. Manual of the flora of the northern states and Canada. Henry Holt and Co., New York. 1080 p.

———, and A. BROWN. 1897. An illustrated flora of the northern United States, Canada, and the British possessions. 1st ed. Vol. II. Charles Scribner's Sons, New York. 643 p.

———, and ———. 1913. An illustrated flora of the northern United States, Canada, and the British possessions. 2nd ed. Vol. II. Charles Scribner's Sons, New York. 680 p.

BUSCH, N. 1915. *Nasturtium. In* Flora Sibiriae et Orientis extremi. Mus. Bot. Acad. Imp. Sci. Petrop. 15: 194-218.

BUTCHER, R. W. 1961. A new illustrated British flora. Vol. I. Leonard Hill [Books] Limited, London. 1016 p.

BUTTERS, F. K., and E. C. ABBE. 1940. The American varieties of *Rorippa islandica.* Rhodora 42: 25-32, pl. 588.

CAPPS, S. R. 1939. Map of Alaska showing extent of present and Quaternary glaciation. pl. 12. *In* P. S. Smith. Areal geology of Alaska. U. S. Geol. Surv., Prof. Pap. 192. 100 p. + 18 pl.

CLAPHAM, A. R., T. G. TUTIN, and E. F. WARBURG. 1962. Flora of the British Isles. 2nd ed. Univ. Press, Cambridge. 1269 p.

DANIELS, F. P. 1911. The flora of Boulder, Colorado, and vicinity. Univ. Missouri Stud. 2: 149-459.

DEAM, C. C. 1940. Flora of Indiana. Dep. Conservation, Division of Forestry, Indianapolis, Indiana. 1236 p.

DESVAUX, N. A. 1814. Coup-d'oeil sur la famille des plantes crucifers. Jour. Bot. Desvaux 3: 145-187.

EASTERLY, N. W. 1964. Distribution patterns of Ohio Cruciferae. Castanea 29: 164-173.

EWAN, J. 1942. Bibliographical miscellany.—IV. A bibliographical guide to the Brandegee botanical collections. Am. Midl. Nat. 27: 772-789.

FASSETT, N. C. 1940. A manual of aquatic plants. McGraw-Hill Book Co., New York. 382 p.

FEATHERLY, H. I. 1954. Taxonomic terminology of the higher plants. Iowa St. Coll. Press, Ames. 166 p.

FERNALD, M. L. 1925. Persistence of plants in unglaciated areas of boreal America. Mem. Am. Acad. 15: 239-342. (Also Mem. Gray Herb. 2)

———. 1928. *Roripa islandica* and *R. hispida.* Rhodora 30: 131-133.

———. 1929. *Roripa islandica* an invalid name. Rhodora 31: 17-18.

———. 1940. The eastern American varieties of *Rorippa islandica.* Rhodora 42: 267-274, pl. 605.

———. 1948a. A prostrate *Rorippa.* Rhodora 50: 35.

———. 1948b. *Rorippa*: A correction. Rhodora 50: 100.

———. 1950. Gray's manual of botany. 8th ed. American Book Co., New York. lxiv + 1632 p.

FLINT, R. F. 1957. Glacial and Pleistocene geology. John Wiley & Sons, New York. 553 p. + 5 pl.

———, R. B. COLTON, R. P. GOLDTHWAIT, and H. B. WILLMAN. 1959. Glacial map of the United States east of the Rocky Mountains. Geol. Soc. Am.

FOSBERG, F. R. 1940. The aestival flora of the Mesilla Valley region, New Mexico. Am. Midl. Nat. 23: 573-593.

GLEASON, H. A. 1952. The New Britton and Brown illustrated flora of the northeastern United States and adjacent Canada. Vol. II. [N. Y. Bot. Gard., New York]. 655 p.

———, and A. CRONQUIST. 1963. Manual of vascular plants of northeastern United

States and adjacent Canada. D. Van Nostrand Co., Princeton. 810 p.

GODWIN, H. 1956. The history of the British flora. A factual basis for phytogeography. Univ. Press, Cambridge. 384 p.

GRAY, A. 1849a. Genera florae Americae Boreali-Orientalis illustrata. The genera of the plants of the United States illustrated by figures and analyses from nature, by Isaac Sprague. Vol. I. George P. Putnam, New York. 230 p. + 100 pl.

———. 1849b. Plantae Fendlerianae Novi-Mexicanae: An account of a collection of plants made chiefly in the vicinity of Santa Fé, New Mexico, by August Fendler; with descriptions of the new species, critical remarks, and characters of other undescribed or little known plants from surrounding regions. Mem. Am. Acad., n.s., 4: 1-116.

———. 1853. Plantae Wrightianae Texano-Neo-Mexicanae: Part II. An account of a collection of plants made by Charles Wright, A.M., in western Texas, New Mexico, and Sonora, in the years 1851 and 1852. Smithsonian Contr. to Knowledge 5(6): 1-119 + tab. 11-14.

———. 1855. Plantae novae Thurberianae: The characters of some new genera and species of plants in a collection made by George Thurber, Esq., of the late Mexican Boundary Commission, chiefly in New Mexico and Sonora. Mem. Am. Acad., n.s., 5: 297-328.

———. 1876. Contributions to the botany of North America. 2. Characters of new species, etc. Proc. Am. Acad. 12: 54-84.

GREEN, P. S. 1962. Watercress in the New World. Rhodora 64: 32-43.

GREENE, E. L. 1891. Flora Franciscana. Part II. Payot, Upham & Co., San Francisco. p. 129-280.

———. 1896. New and noteworthy species—XVII. Pittonia 3: 91-98.

———. 1905. The genus *Radicula*. Leafl. Bot. Obs. & Crit. 1: 113-114.

GROH, H. 1933. Some recently noticed mustards. Sci. Agr. 13: 722-727.

———. 1936. Creeping yellow cress. Sci. Agr. 16: 331-334.

HANSEN, A. A. 1922. Austrian field cress: A new weed in the United States. Torreya 22: 73-77.

HARRINGTON, H. D. 1954. Manual of the plants of Colorado. Alan Swallow, Denver. 666 p.

HARRIS, S. K. 1958. *Rorippa sessiliflora* in Essex County, Massachusetts. Rhodora 60: 260-261.

HEMSLEY, W. B. 1879. Biologia Centrali-Americana; or, contributions to the knowledge of the fauna and flora of Mexico and Central America. Botany. Vol. I. London. 576 p.

HITCHCOCK, A. S., and P. C. STANDLEY. 1919. Flora of the District of Columbia and vicinity. Contr. U. S. Natl. Herb. 21: 1-329 + 42 pl.

HITCHCOCK, C. L., and A. CRONQUIST. 1964. Vascular plants of the Pacific Northwest. Part 2. Salicaceae to Saxifragaceae. Univ. Wash. Publ. Biol. 17: 1-597.

HOLZINGER, J. M. 1892. List of plants collected by C. S. Sheldon and M. A. Carleton in Indian Territory in 1891. Contr. U. S. Natl. Herb. 1: 189-219.

HOWELL, T. 1897. A flora of Northwest America. Vol. I. Portland. 792 p. + index.

HULTÉN, E. 1937. Outline of the history of arctic and boreal biota during the Quarternary [sic] Period. Bokforlags Aktiebolaget Thule, Stockholm. 168 p. + 43 pl.

———. 1945. Flora of Alaska and Yukon V. Lunds Univ. Arsskr. II. Sect. 2. 41: 797-978.

———. 1950. Atlas over vaxternas utbredning i norden. General stabens Litografiska Anstalts Forlag, Stockholm. 512 p.

HUSSEY, R. C. 1947. Historical geology, 2nd ed. McGraw-Hill Book Co., New York. 465 p.

ILTIS, H. H. 1965. The genus *Gentianopsis* (Gentianaceae): Transfers and phytogeographic comments. Sida 2: 129-154.

JENSEN, L. A. 1955. New noxious weed found in Sevier Co. Farm & Home Sci. (Utah Sta.) 16: 69, 84.

JEPSON. W. L. 1925. A manual of the flowering plants of California. Associated Students Store, Univ. Calif., Berkeley. 1238 p.

———. 1936. A flora of California. Vol. II. Capparidaceae to Cornaceae. Calif. School Book Depository, San Francisco. 684 p.

JONES, G. N. 1963. Flora of Illinois. Am. Midl. Nat. Monogr. No. 7. 401 p.

———, and G. D. FULLER. 1955. Vascular plants of Illinois. Univ. Ill. Press, Urbana. 593 p.

JONES, M. E. [Undated]. An account of the botanical collecting of Marcus E. Jones during the years 1875 to 1919. Manuscript in the Library of the Division of Plants, United States National Museum, Washington. Copy in Univ. of Mich. Lib.

JONSELL, B. 1968. Studies in the north-west European species of *Rorippa* s. str. Symb. Bot. Upsal. 19: 1-221 + 11 pl.

JORDAN, D. S. 1905. The origin of species through isolation. Science 22: 545-562.

KEARNEY, T. H., and R. H. PEEBLES. 1951. Arizona flora. 1st ed. Univ. Calif. Press, Berkeley & Los Angeles. 1032 p.

LARUE, C. D. 1943. Regeneration in *Radicula aquatica*. Pap. Mich. Acad. 28: 51-61. ["1942"]

LAWRENCE, G. H. M. 1951. Taxonomy of vascular plants. The Macmillan Co., New York. 823 p.

MACKENZIE, K. K. 1925. The name *Sisymbrium*. Rhodora 27: 28-32.

————. 1929. The generic name *Radicula*. Rhodora 31: 119.

MARIE-VICTORIN, FRÈRE. 1930. Le genre *Rorippa* dans le Quebec. Contr. Inst. Bot. Univ. Montréal 17: 1-17.

————. 1938. Phytogeographical problems of eastern Canada. Am. Midl. Nat. 19: 489-558.

————. 1947. Flore Laurentienne. Les Frères des Ecoles Chrétiennes. Montréal. 916 p.

MASON, H. L. 1957. A flora of the marshes of California. Univ. Calif. Press, Berkeley & Los Angeles. 878 p.

MASSEY, A. B. 1961. Virginia flora. Va. Agr. Exp. Sta. Tech. Bull. 155. 258 p.

McVAUGH, R. 1956. Edward Palmer: Plant explorer of the American West. Univ. Okla. Press, Norman. 430 p.

MONACHINO, J. 1957. Adventive plants in New York. Rhodora 59: 17-20.

MUENSCHER, W. C. 1942. Weeds. The Macmillan Co., New York. 579 p.

MULLIGAN, G. A., and A. E. PORSILD. 1966. *Rorippa calycina* in the Northwest Territories. Canad. Jour. Bot. 44: 1105-1106.

————, and ————. 1968. A natural first-generation hybrid between *Rorippa barbareaefolia* and *R. islandica*. Canad. Jour. Bot. 46: 1079-1081.

MUNZ, P. A., and D. D. KECK. 1959. A California flora. Univ. Calif. Press, Berkeley & Los Angeles. 1681 p.

MURLEY, M. R. 1951. Seeds of the Cruciferae of northeastern North America. Am. Midl. Nat. 46: 1-81.

MUSIL, A. F. 1963. Identification of crop and weed seeds. Agriculture Handbook No. 219. U. S. Dep. Agr., Washington, D. C. 171 p. + 43 pl.

NICOLLETT, J. N. 1843. Report intended to illustrate a map of the hydrographical basin of the upper Mississippi River, made by I. N. Nicollett while in employ under the Bureau of the Corps of Topographical Engineers. Blair and Rivers, Washington. 142 p.

NORTON, A. H. 1933. *Rorippa amphibia* in Androscoggin County, Maine. Rhodora 35: 262.

OVER, W. H. 1932. Flora of South Dakota. Univ. S. D., Vermillion. 161 p.

PAMMEL, L. H., and C. M. KING. 1926. The weed flora of Iowa. Rev. ed. Iowa Geol. Surv. Bull. No. 4. 715 p.

————, ————, and A. HAYDEN. 1929. Marsh cress, a bad weed. Iowa Agr. Exp. Sta. Circ. No. 120, p. 1-8.

————, ————, and ————. 1930. Marsh cress, its geography and ecology in Iowa. Proc. Iowa Acad. Sci. 35: 157-167.

PARRY, C. C. 1852. Systematic catalogue of plants of Wisconsin and Minnesota, by C. C. Parry, M.D., made in connection with the geological survey of the northwest, during the season of 1848, p. 606-622. *In* D. D. Owen. Report of a Geological Survey of Wisconsin, Iowa, and Minnesota; and incidentally of a portion of Nebraska Territory. Made under instructions from the United States Treasury Department. Lippincott, Grambo & Co., Philadelphia. 638 p.

PATMAN, J., and H. H. ILTIS. 1961. Preliminary reports on the flora of Wisconsin No. 44 Cruciferae—Mustard Family. Trans. Wisconsin Acad. 50: 17-72.

PAYSON, E. B. 1921. A monograph of the genus *Lesquerella*. Ann. Missouri Bot. Gard. 8: 103-236.

PECK, M. E. 1941. A manual of the higher plants of Oregon. Binfords & Mort, Portland. 866 p. + errata.

————. 1961. A manual of the higher plants of Oregon. 2nd ed. Binfords & Mort, Portland. 936 p.

PIPER, C. V. 1906. Flora of the state of Washington. Contr. U. S. Natl. Herb. 11: 1-637.

POLAKOWSKY, H. 1877. Plantas Costaricenses anno 1875 lectas. Linnaea 41: 545-598.

PORSILD, A. E. 1939. Conrtibutions to the flora of Alaska. Rhodora 41: 141-183, 199-254, 262-301.

__________. 1951. Botany of southeastern Yukon adjacent to the Canol Road. Nat. Mus. Canada Bull. 121. 400 p.

POWELL, J. W. 1875. Exploration of the Colorado River of the west and its tributaries explored in 1869, 1870, 1871, and 1872, under the direction of the Secretary of the Smithsonian Institution, Washington. 285 p.

ROLLINS, R. C. 1941. Some new or noteworthy North American crucifers. Contr. Dudley Herb. 3: 174-184 + pl. No. XLVI.

__________. 1957. Miscellaneous Cruciferae of Mexico and western Texas. Rhodora 59: 61-71.

__________. 1960. The American Cruciferae of Sessé and Mociño. Rhodora 62: 11-20.

__________. 1961. Notes on American *Rorippa* (Cruciferae). Rhodora 63: 1-10.

__________. 1962. A new crucifer from the Great Slave Lake area of Canada. Rhodora 64: 324-327.

__________. 1969. On a weed species of *Rorippa*. Rhodora 71: 552-553.

ROSE, J. N. 1895. Report on a collection of plants made in the states of Sonora and Colima, Mexico, by Dr. Edward Palmer, in the years 1890 and 1891. Contr. U. S. Natl. Herb. 1: 293-366.

ROTHROCK, J. T. 1868. Sketch of the flora of Alaska. Annual Rep. Board Regents Smithsonian Institution, p. 431-463.

__________. 1878. Catalogue of plants collected in Nevada, Utah, Colorado, New Mexico, and Arizona with descriptions of those not contained in Gray's Manual of the northern U.S., and Vol. V, geological exploration of the fortieth parallel, p. 53-297. *In* Report upon United States Geographical Surveys west of one hundredth meridian, in charge of First Lieut. Geo. M. Wheeler . . . . Vol. VI.—Botany. Government Printing Office, Washington. 404 p. + 30 pl.

RYDBERG, P. A. 1906. Flora of Colorado. Agr. Exp. Sta. Bull. 100, Fort Collins, Colorado.

__________. 1922. Flora of the Rocky Mountains and adjacent plains. 2nd ed. Publ. by the author, New York. 1143 p.

SCHULZ, O. E. 1903. IX. Cruciferae. *In* I. Urban, Symb. Antill. 3: 493-523.

__________. 1933. Beiträge zur Kenntnis der Gattung *Nasturtium*. R. Br. II. Repert. Sp. Nov. 34: 131-136.

SCOGGAN, H. J. 1957. Flora of Manitoba. Natl. Mus. Canada Bull. No. 140. 619 p.

SEEMANN, B. 1852-1857. The botany of the voyage of H. M. S. Herald, under the command of Captain Henry Kellett, R. N. C. B. During the years 1845-51. Lovell Reeve, London. 483 p. + 100 pl.

SHREVE, F., and I. L. WIGGINS. 1964. Vegetation and flora of the Sonoran Desert. Vol. I. Stanford Univ. Press, Stanford, Calif. 840 p.

SMALL, J. K. 1913. Flora of the southeastern United States. Publ. by the author, New York. 1394 p.

__________. 1923. The Austrian field-cress again. Torreya 23: 23-25.

__________. 1933. Manual of the southeastern flora. Publ. by the author, New York. 1554 p.

SPRAGUE, T. A. 1924. The botanical name of water-cress. Jour. Bot. London 62: 225-228.

__________. 1930. The source of the generic name *Rorippa*. Jour. Bot. London 68: 219-220.

STANDLEY, P. C. 1921. Flora of Glacier National Park Montana. Contr. U. S. Natl. Herb. 22: 235-438.

__________. 1931. Flora of the Lancetilla Valley Honduras. Field Mus. Publ. Bot. 10: 1-418 + 68 pl.

__________. 1937. Flora of Costa Rica. Part II. Field Mus. Publ. Bot. 18: 401-780.

__________, and J. A. STEYERMARK. 1946. Flora of Guatemala. Fieldiana Bot. 24: 1-493.

STEVENS, O. A. 1950. Handbook of North Dakota plants. N. D. Agr. Coll., Fargo. 324 p.

STEYERMARK, J. A. 1963. Flora of Missouri. Iowa St. Univ. Press, Ames. 1725 p.

STRAUSBAUGH, P. D., and E. L. CORE. 1953. Flora of West Virginia. Part II. W. Va. Univ. Bull. Ser. 53, No. 12-1. p. 275-570.

STUCKEY, R. L. 1966a. Differences in habitats and associates of the varities of *Rorippa islandica* in the Douglas Lake region of Michigan. Mich. Bot. 5: 99-108.

__________. 1966b. The distribution of *Rorippa sylvestris* (Cruciferae) in North America. Sida 2: 361-376.

__________. 1966c. *Rorippa walteri* and *R. obtusa* synonyms of *R. teres* (Cruciferae). Sida 2: 409-418.

THORNE, R. F. 1954. The vascular plants of southwestern Georgia. Am. Midl. Nat. 52: 257-327.

TORREY, J. 1857. Description of the general botanical collections, p. 61-167 + 25 pl. *In* Reports of explorations and surveys, to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean, made under the direction of the secretary of war, in 1853-54, . . . Vol. IV. Part V. Washington. 288 p.

________. 1859. Botany of the boundary, p. 27-270 + 61 pl. *In* Report on the United States and Mexican boundary survey, made under the direction of the Secretary of the Interior, by William H. Emory . . . . Vol. II. Part I. Washington.

________, and A. GRAY. 1838-1843. A flora of North America: containing abridged descriptions of all the known indigenous and naturalized plants growing north of Mexico; arranged according to the natural system. 2 vols. Wiley and Putnam, New York. 771 p. and 504 p.

TURNER, L. M. 1886. Contributions to the natural history of Alaska. Part III. Plants, p. 61-85. Government Printing Office, Washington. 226 p. + 26 pl.

URBAN, I. 1902. I. Bibliographia Indiae Occidentalis botanica. Symb. Antill. 3: 1-146.

VALENTINE, D. H. 1964. *Rorippa*, p. 283-284. *In* Flora Europaea. Vol. I. Univ. Press, Cambridge. 464 p.

WALPOLE, B. A. 1927. Distribution of the Cruciferae in Michigan. Pap. Mich. Acad. 6: 307-349. ["1926"]

WANNENMACHER, R. 1960. Cruciferae. p. 73-514. *In* Hegi Illustrierte Flora Mittel-Europa. 2nd ed. Bd. IV. Teil 2. Carl Hanser, München. 547 p.

WATSON, S. 1895. *Nasturtium*. p. 146-149. *In* A. Gray, Synoptical flora of North America. Vol. I. Part I. American Book Co., New York. 506 p.

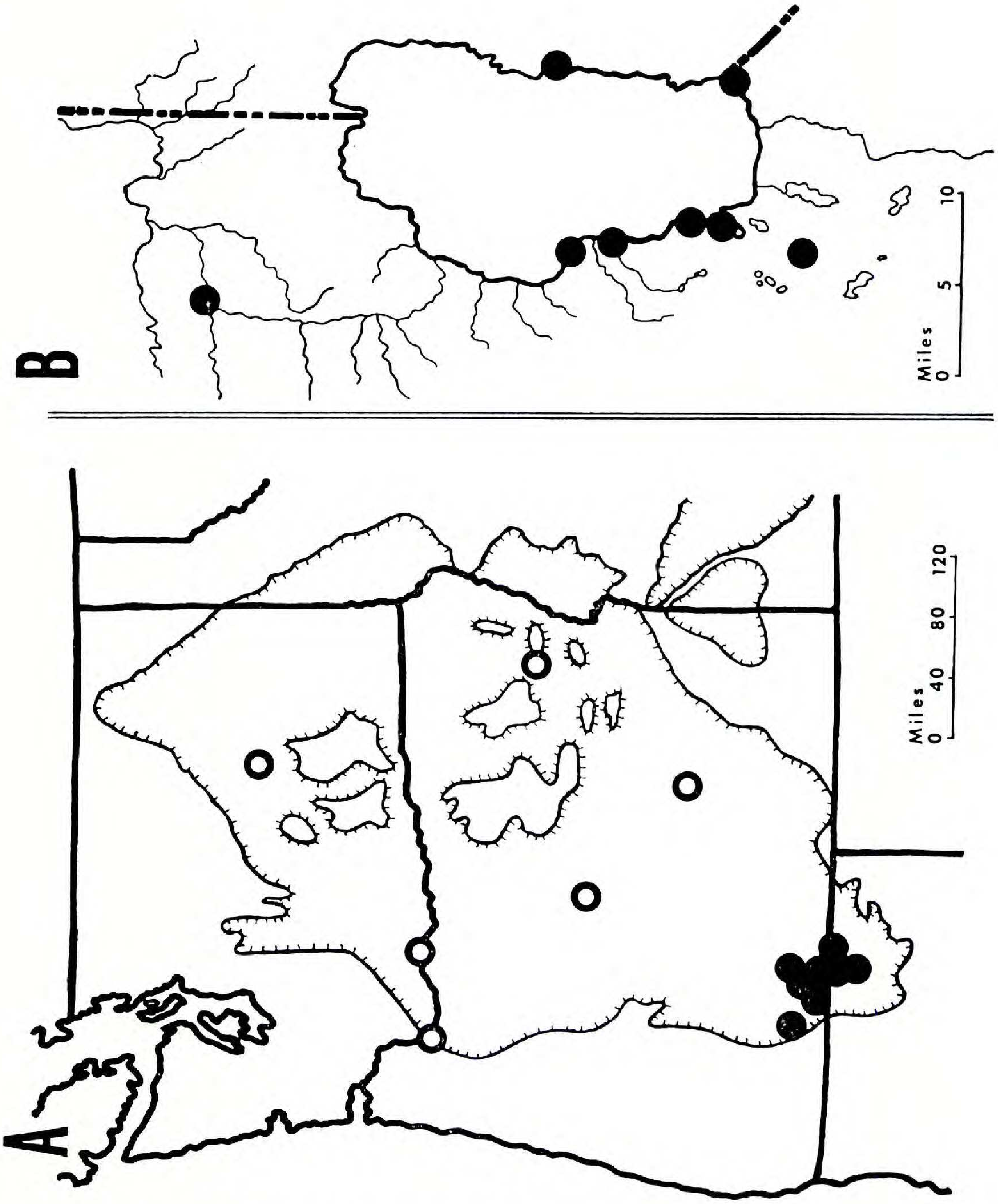
WILSON, G. W. 1906. Notes on some new or little known members of the Indiana flora. Proc. Indiana Acad. Sci. 165-175. ["1905"]

WINTER, J. M. 1936. An analysis of the flowering plants of Nebraska. Contr. Bot. Surv. Nebraska No. 10. 203 p.

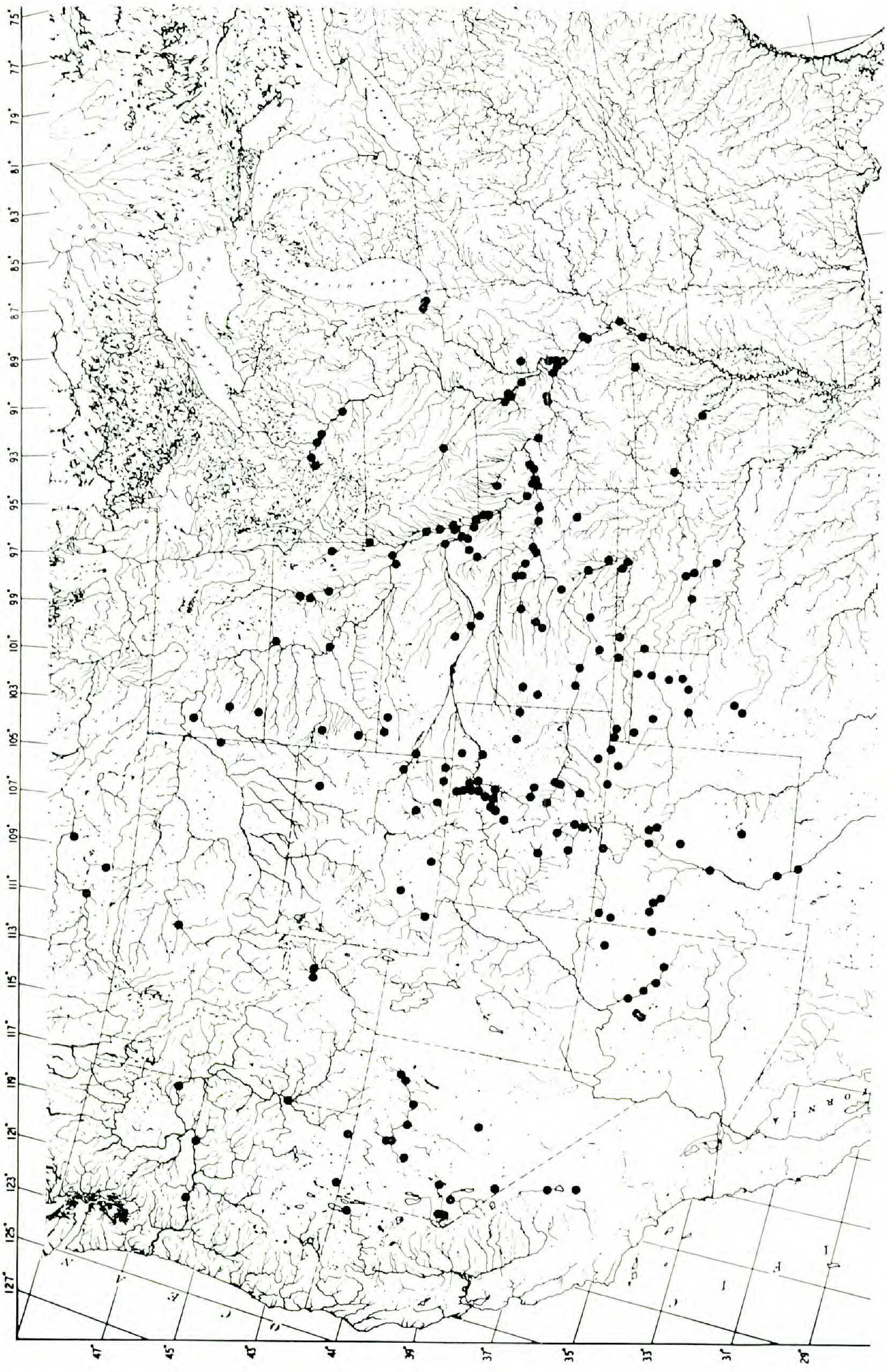
WOLDEN, B. O. 1956. The flora of Emmet County, Iowa. Proc. Iowa Acad. Sci. 63: 118-156.

WOOTON, E. O., and P. C. STANDLEY. 1915. Flora of New Mexico. Contr. U. S. Natl. Herb. 19: 1-794.

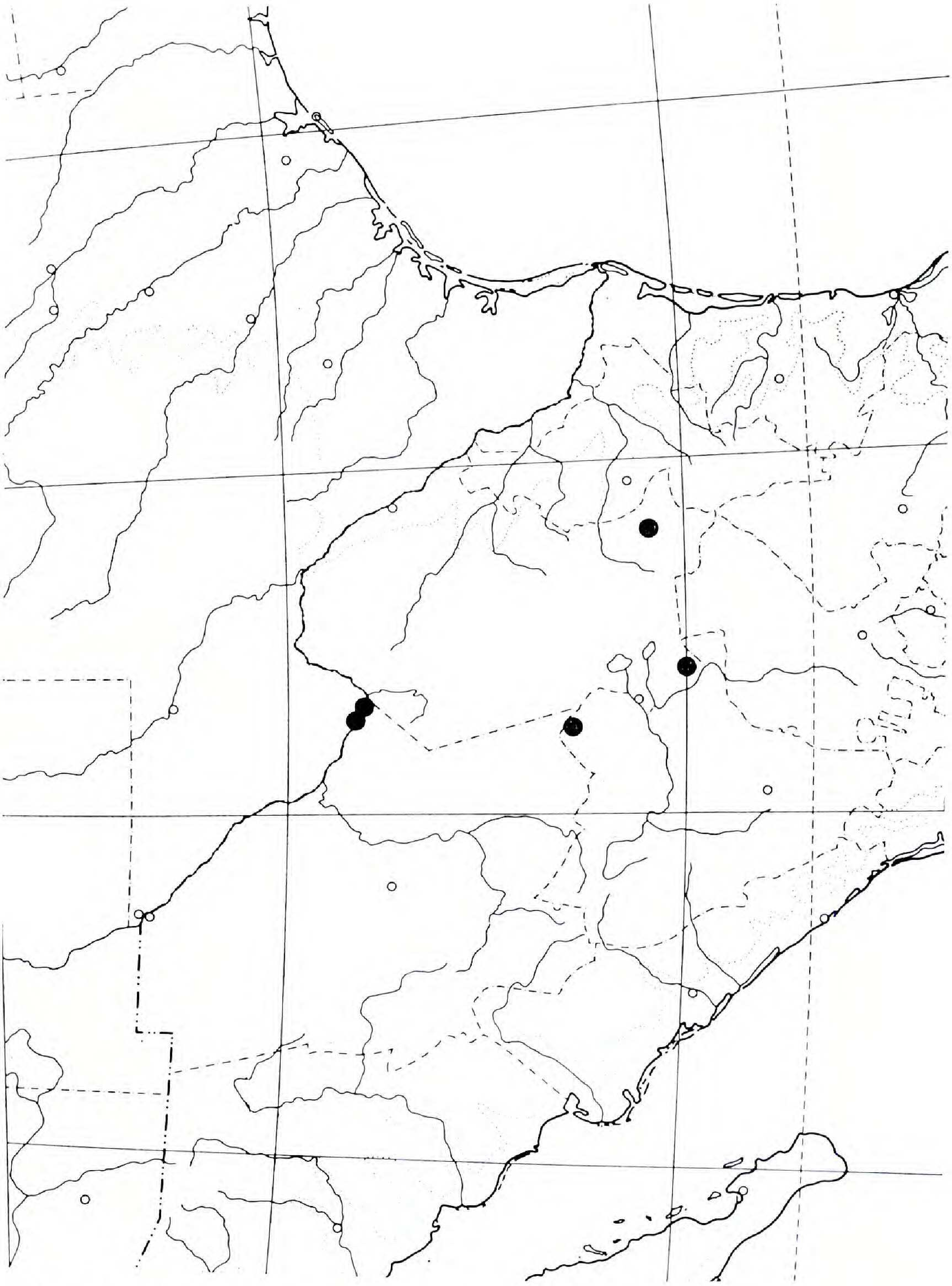
WYNNE-EDWARDS, V. C. 1937. Isolated arctic-alpine floras in eastern North America: A discussion of their glacial and recent history. Trans. Roy. Soc. Canada 31, ser. 3: 33-58.



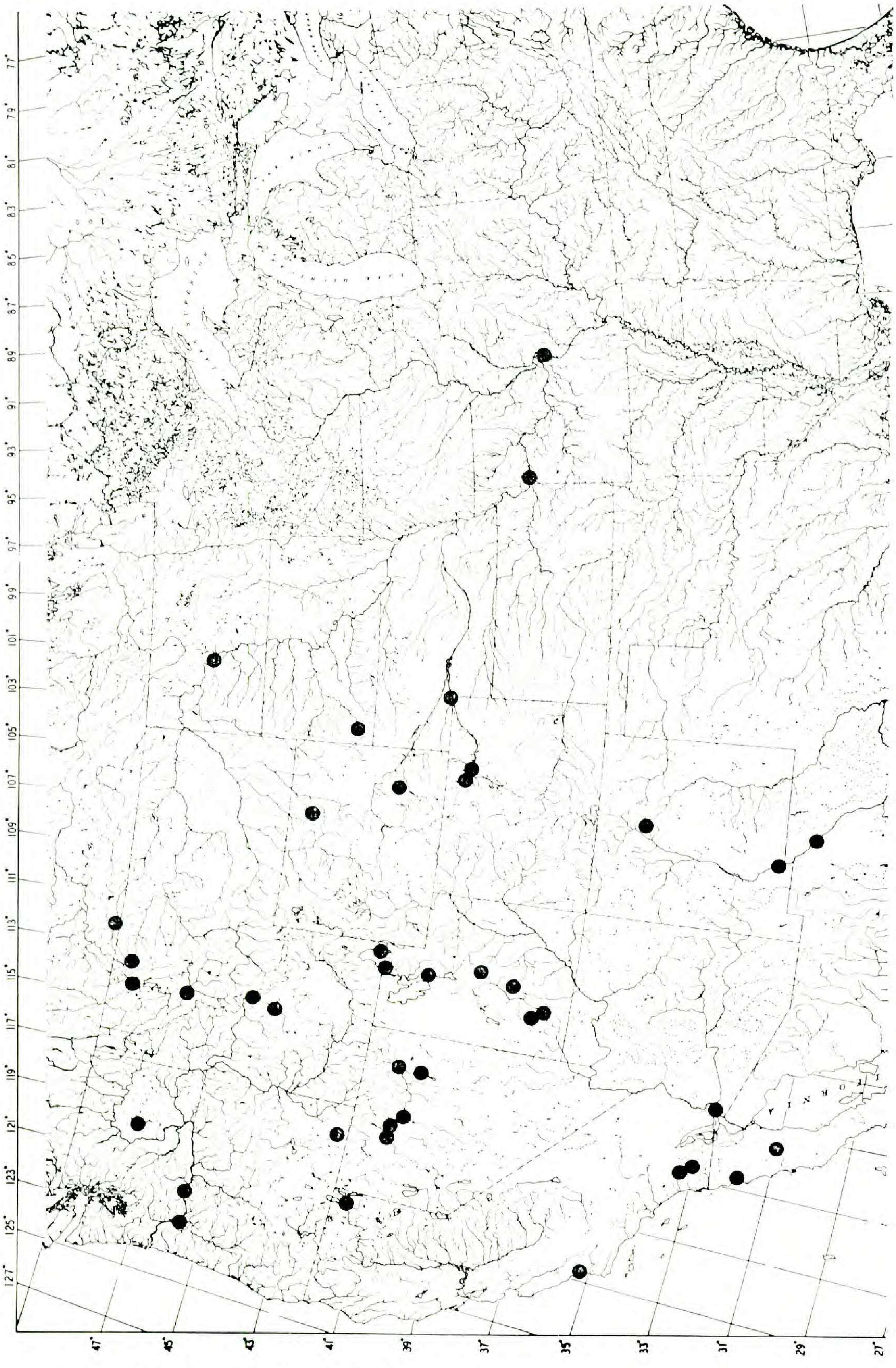
Map 1. Distribution of two endemic species of section *Sinuatae*. A. *Rorippa columbiae* in northwestern United States: The area enclosed by the half-barred line marks the limits of the Columbia River basaltic lava plateau of Tertiary age (after Hussey, 1947, p. 356). Circles represent collections made before 1905. Dots represent collections made since 1905. B. *Rorippa subumbellata* about Lake Tahoe and vicinity: The dot to the northwest is an old collection "collected at Truckee"; the dot to the southwest is an old collection "collected at Tallac Lake (near Tahoe)." (From a map of "Lake Tahoe Region, California State Automobile Association.")



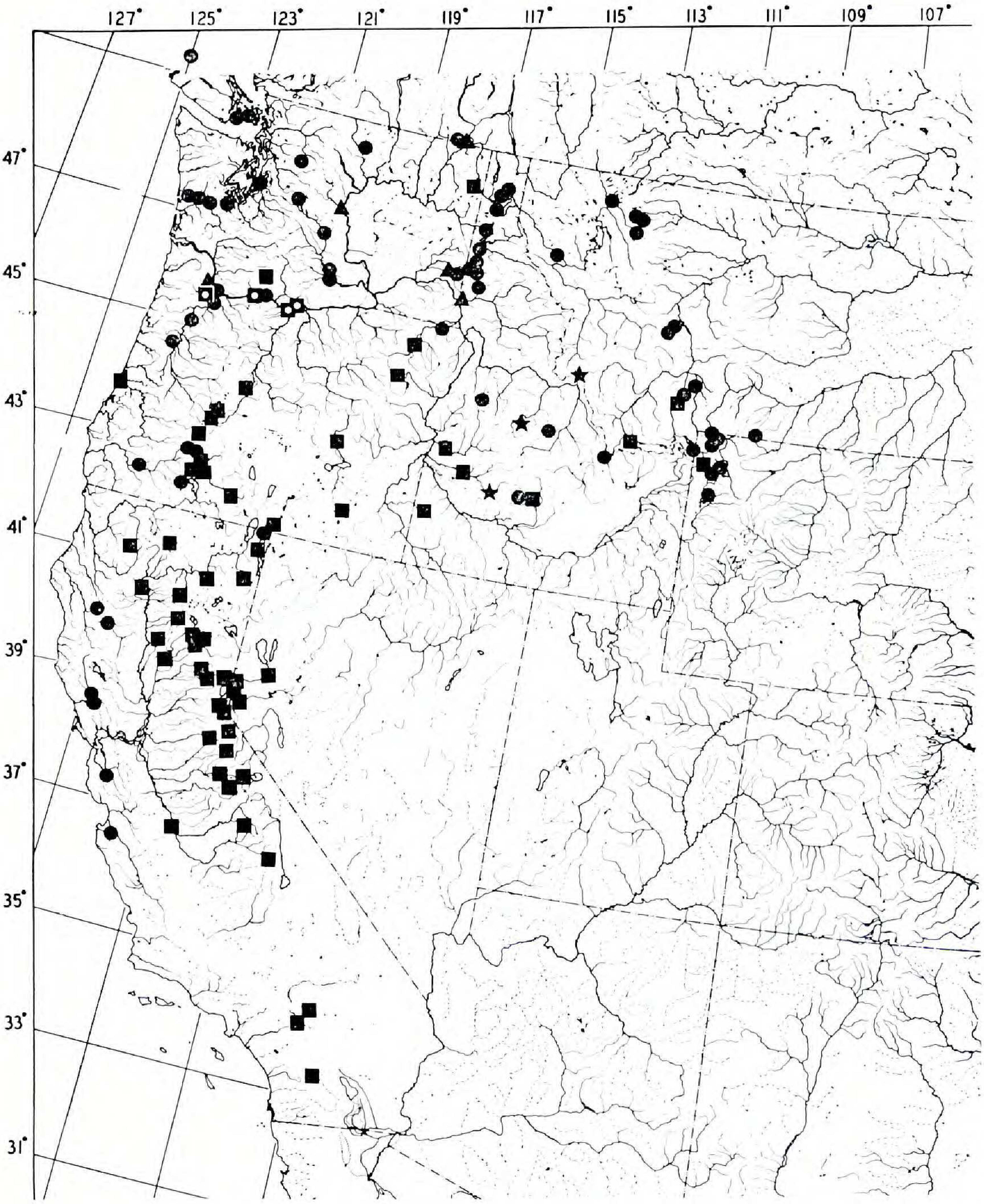
Map 2. Distribution of *Rorippa sinuata*.



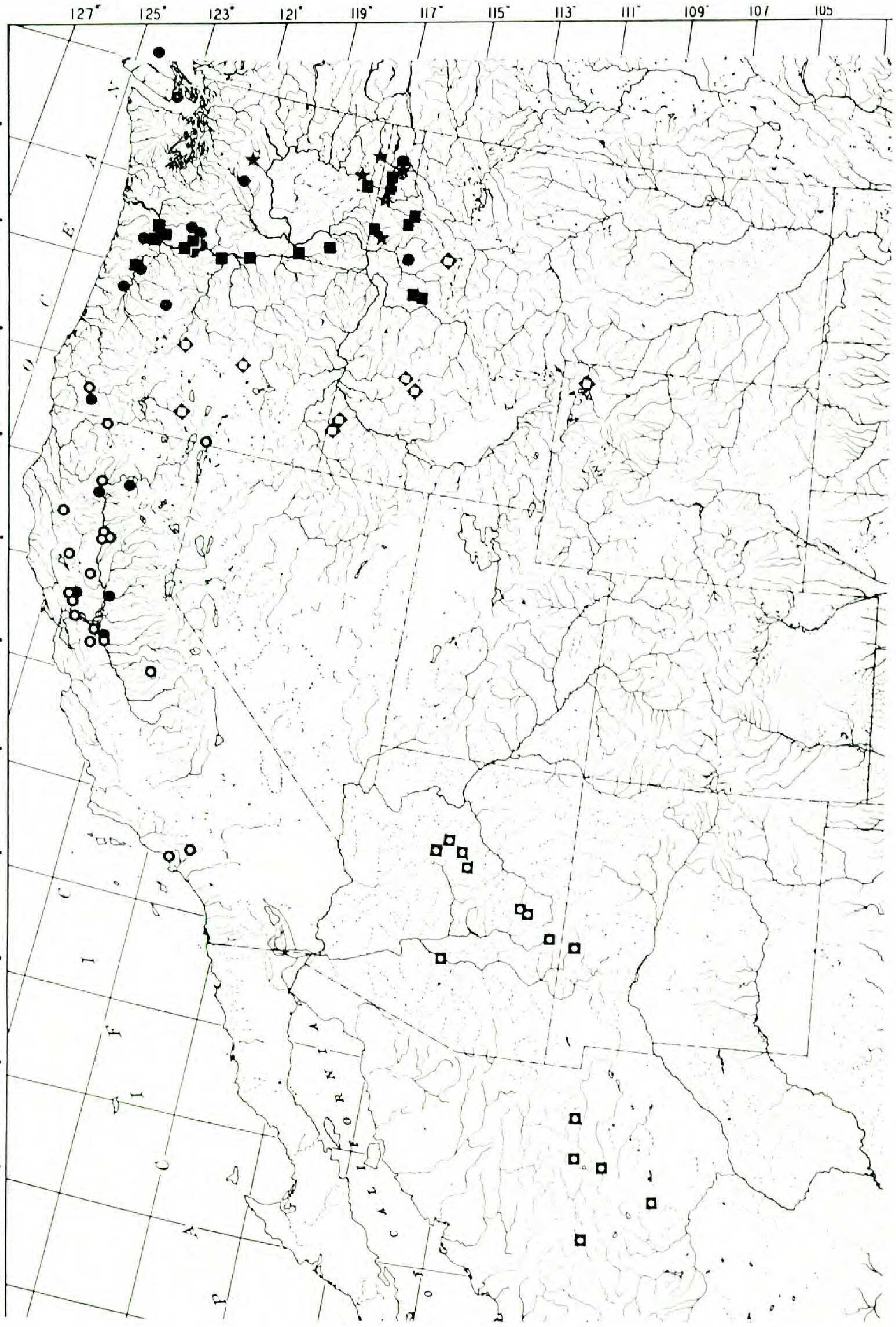
Map 3. Distribution of *Rorippa ramosa*.



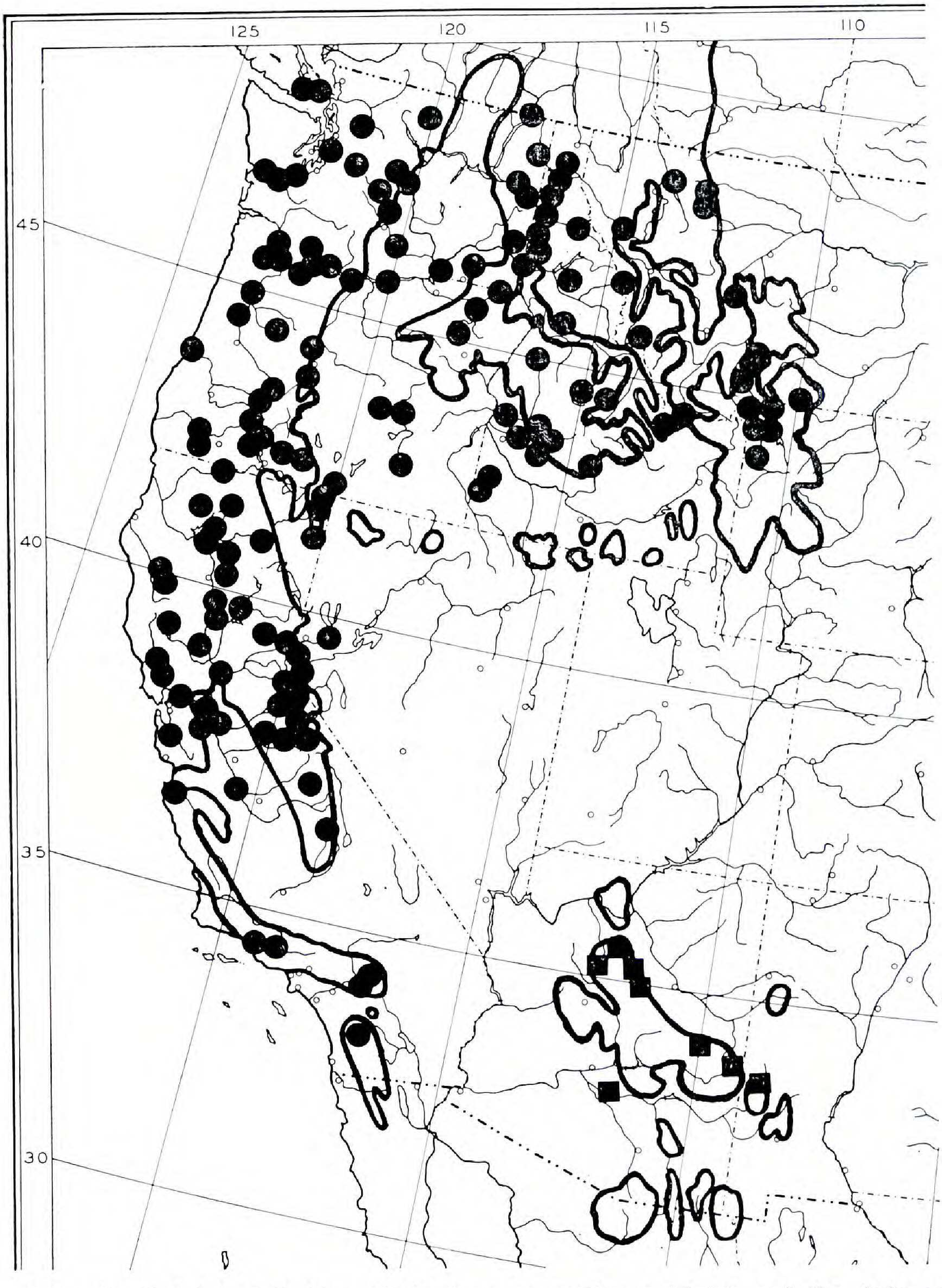
Map 4. Distribution of *Rorippa tenerrima*.



Map. 5. Distribution of the "pectinate-pinnatifid leaved" members of *Rorippa curvisiliqua* in western United States: ● *R. curvisiliqua* var. *curvisiliqua*, □ *R. curvisiliqua* var. *nuttallii*, ■ *R. curvisiliqua* var. *orientalis*, ▲ intermediates between var. *curvisiliqua* and var. *nuttallii*, ★ intermediates between var. *curvisiliqua* and var. *orientalis*.



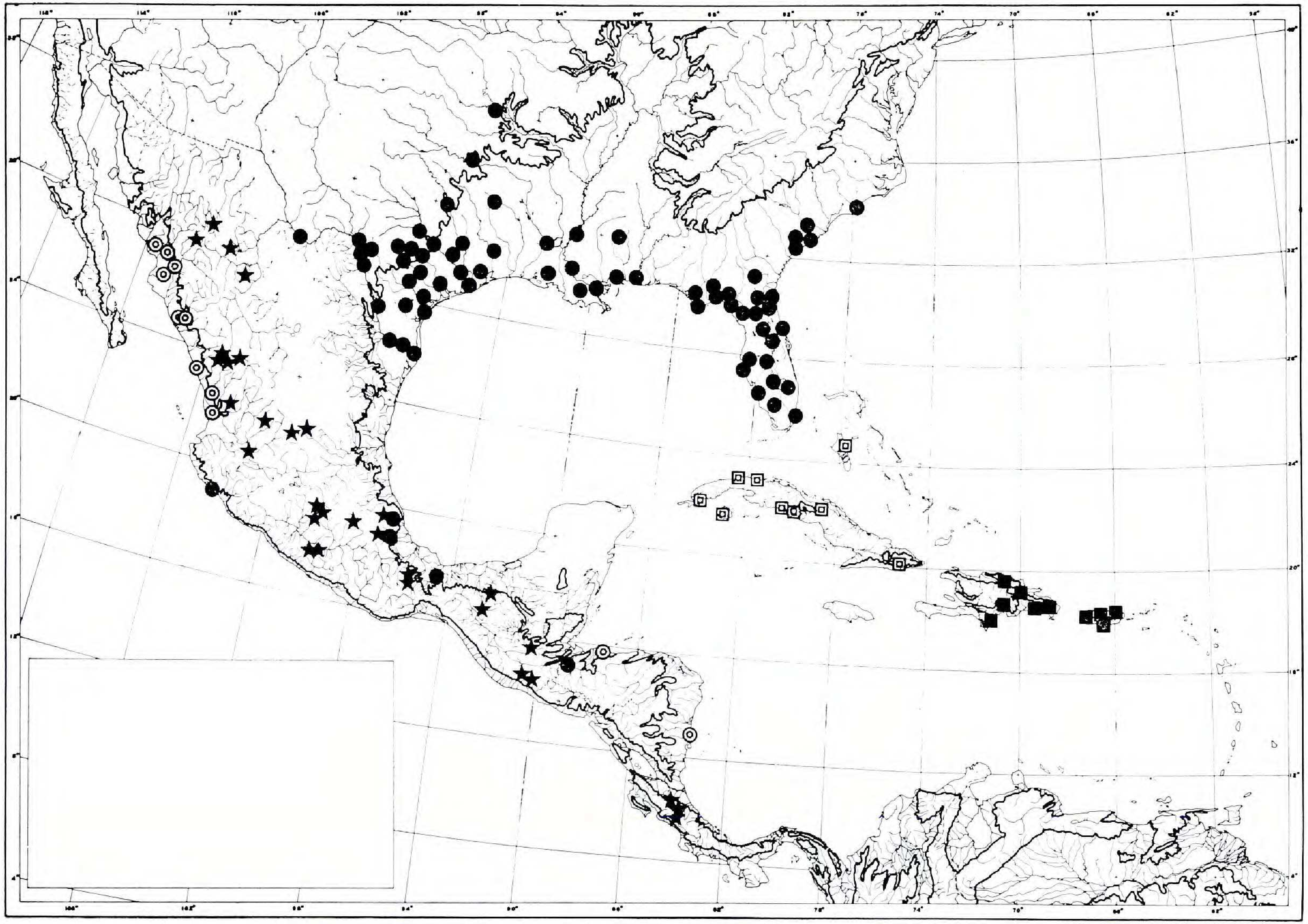
Map 6. Distribution of the "pinnatifid-spatulate leaved" members of *Rorippa curvisiliqua* and *R. microtitis*: ● *R. curvisiliqua* var. *procumbens*, ■ *R. curvisiliqua* var. *lyrata*, ◇ *R. curvisiliqua* var. *spatulata*, ○ *R. curvisiliqua* var. *occidentalis*, ★ intermediates between var. *procumbens* and var. *lyrata*, □ *R. microtitis*.

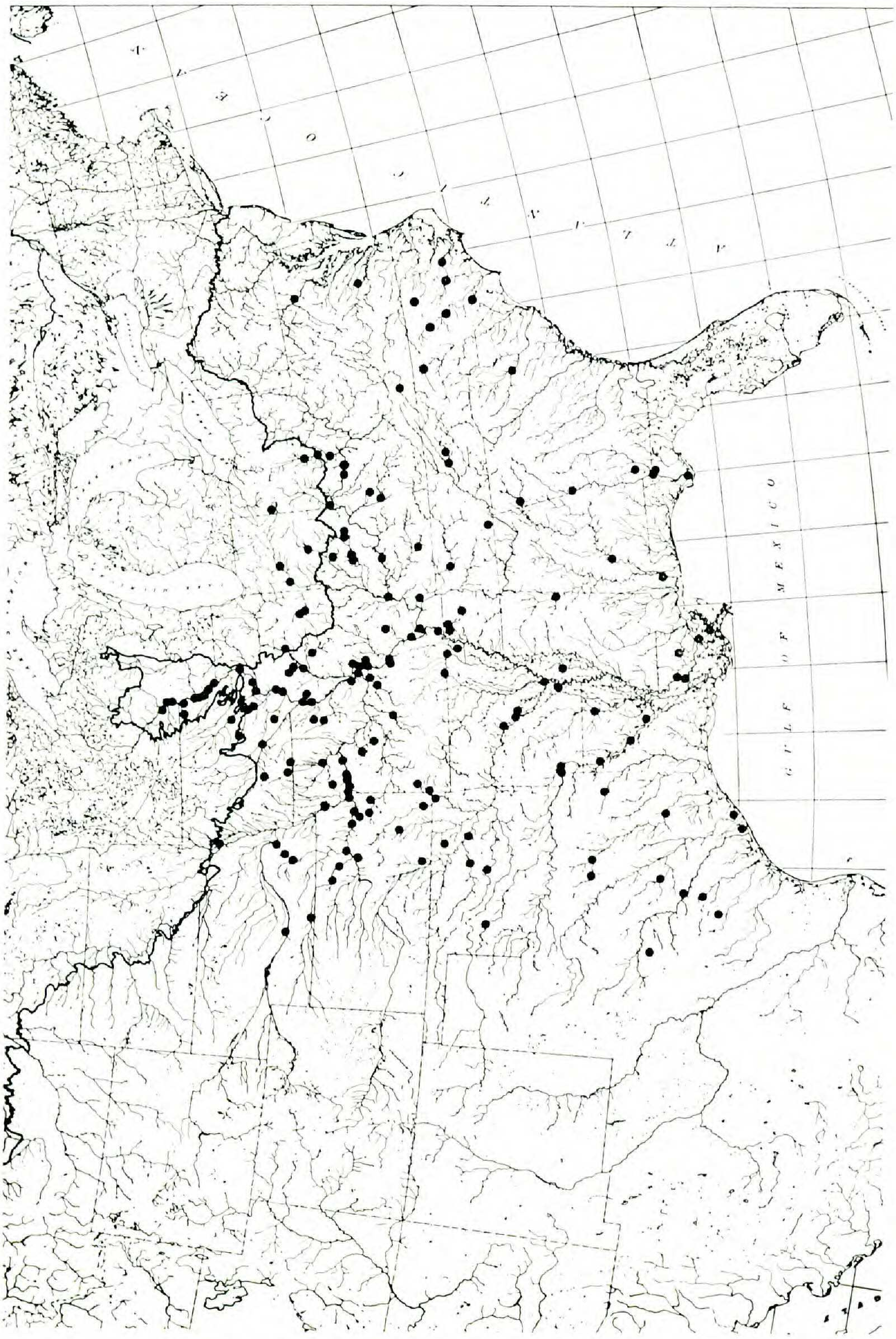


Map 7. Total distribution of *Rorippa curvisiliqua* (dots) and the Arizona and New Mexico distribution of *Rorippa microtitis* (squares) shown in relation to the 16-inch annual rainfall isohyet for western United States. Both species are largely confined to an area that receives more than 16 inches of rainfall a year. (Rainfall data are taken from a 1963 ed. of a map showing normal annual total precipitation (inches), based on data from 1931-60, prepared by the Office of Climatology, U. S. Dep. of Commerce Weather Bureau, U. S. Govt. Printing Office.)

Map 8. Distribution of certain related species of *Rorippa* in southern United States, Mexico, Central America, and the West Indies: ★ *R. mexicana.* This species is in the uplands; ● *R. teres* var. *teres*; ◎ *R. teres* var. *rollinsii.* This species is limited to the Coastal Plain of the continent, except in two places, western Texas of the United States and Veracruz of Mexico. The line marks the 200 meter contour; ■ *R. portoricensis* var. *portoricensis*; ⧈ *R. portoricensis* var. *pumilum.* This species is absent from the western part of the island of Hispaniola in Haiti.

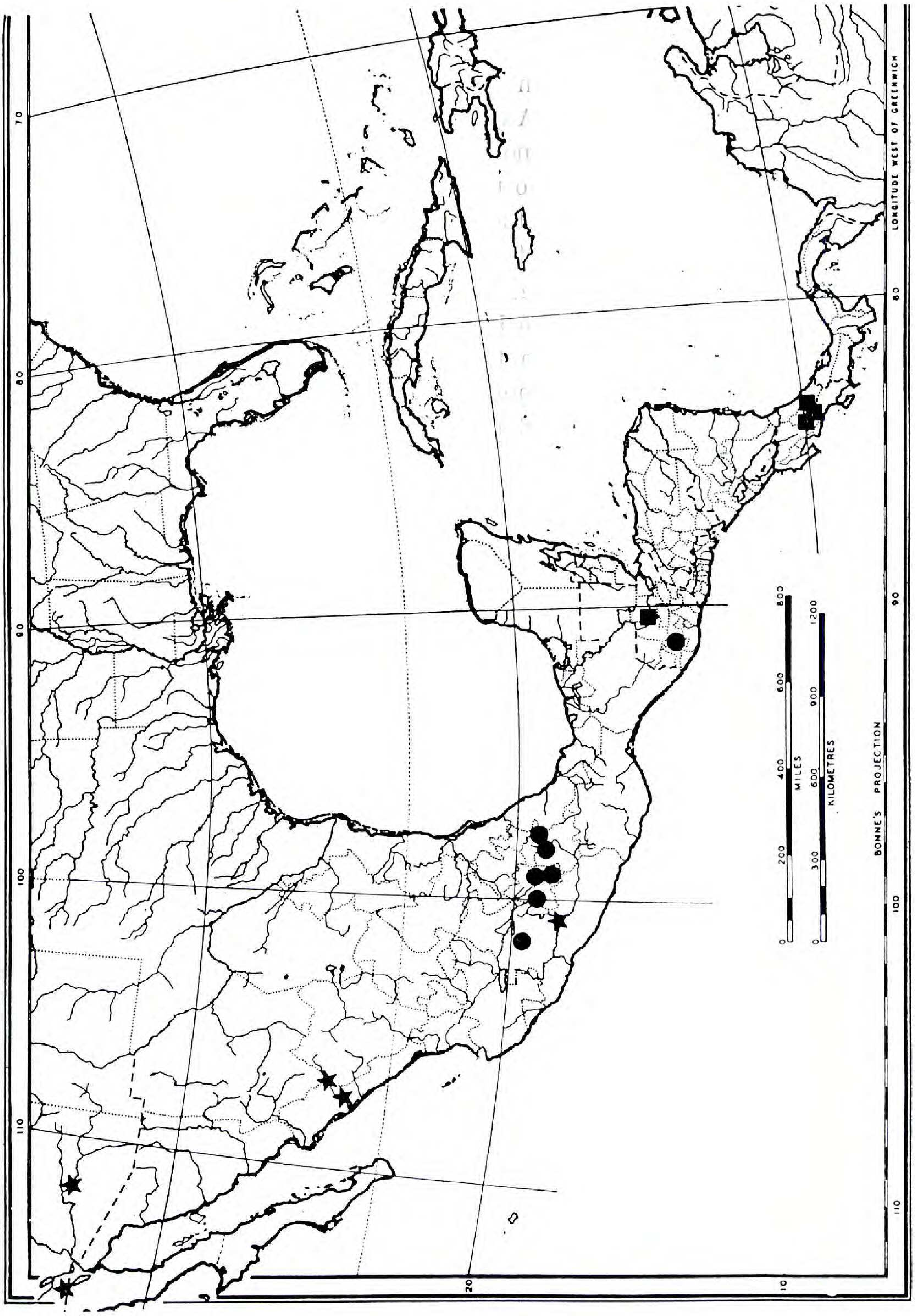
The solid line marks the 200 meter line of elevation throughout the map. The data are taken from two American Geographical Society maps, edition 1-AMS reprinted by Army Map Service (1949), and edition 2-AGS reprinted by Army Map Service (1952).



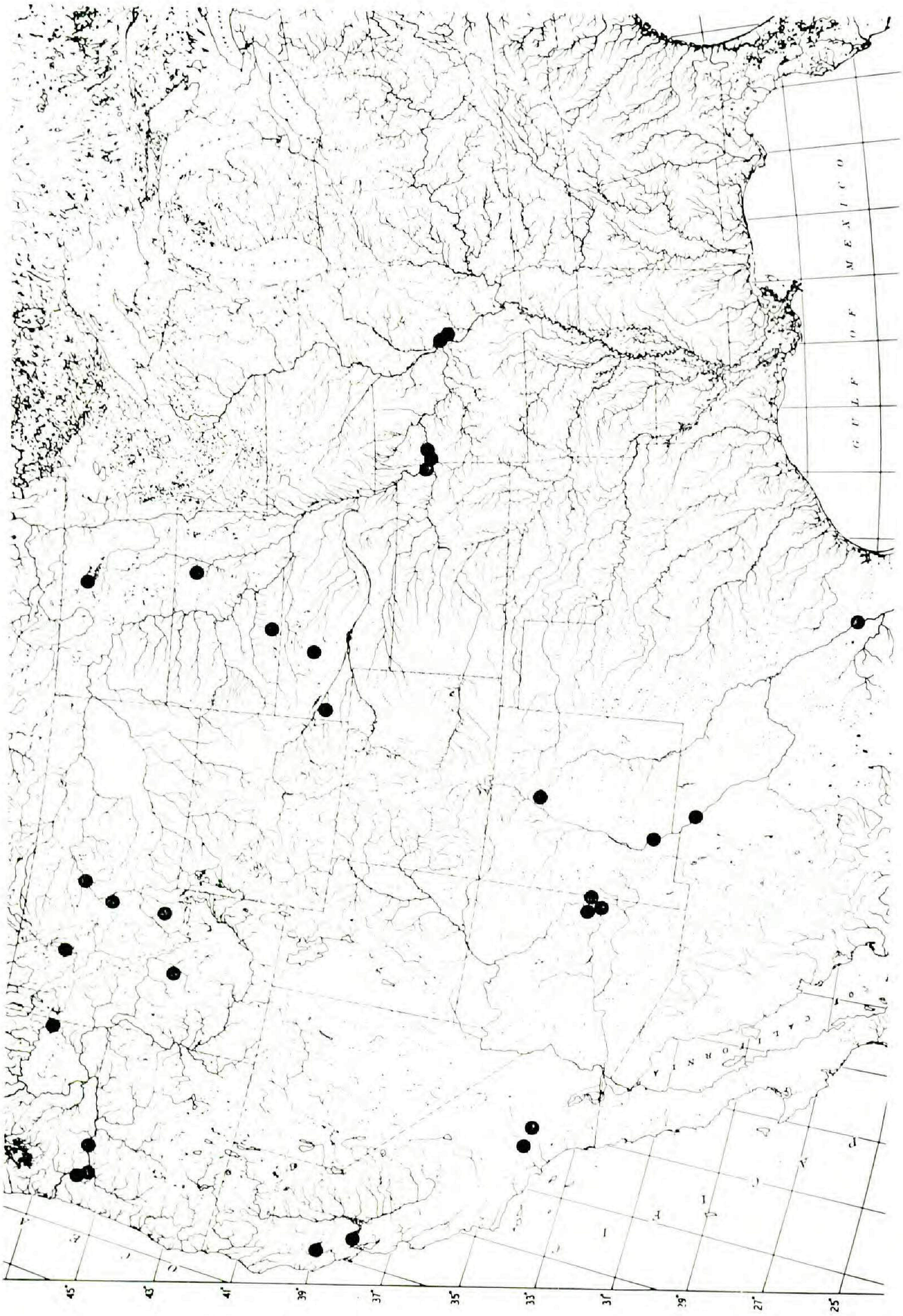


Map 9. Distribution of *Rorippa sessiliflora* in the Mississippi embayment and southeastern United States.

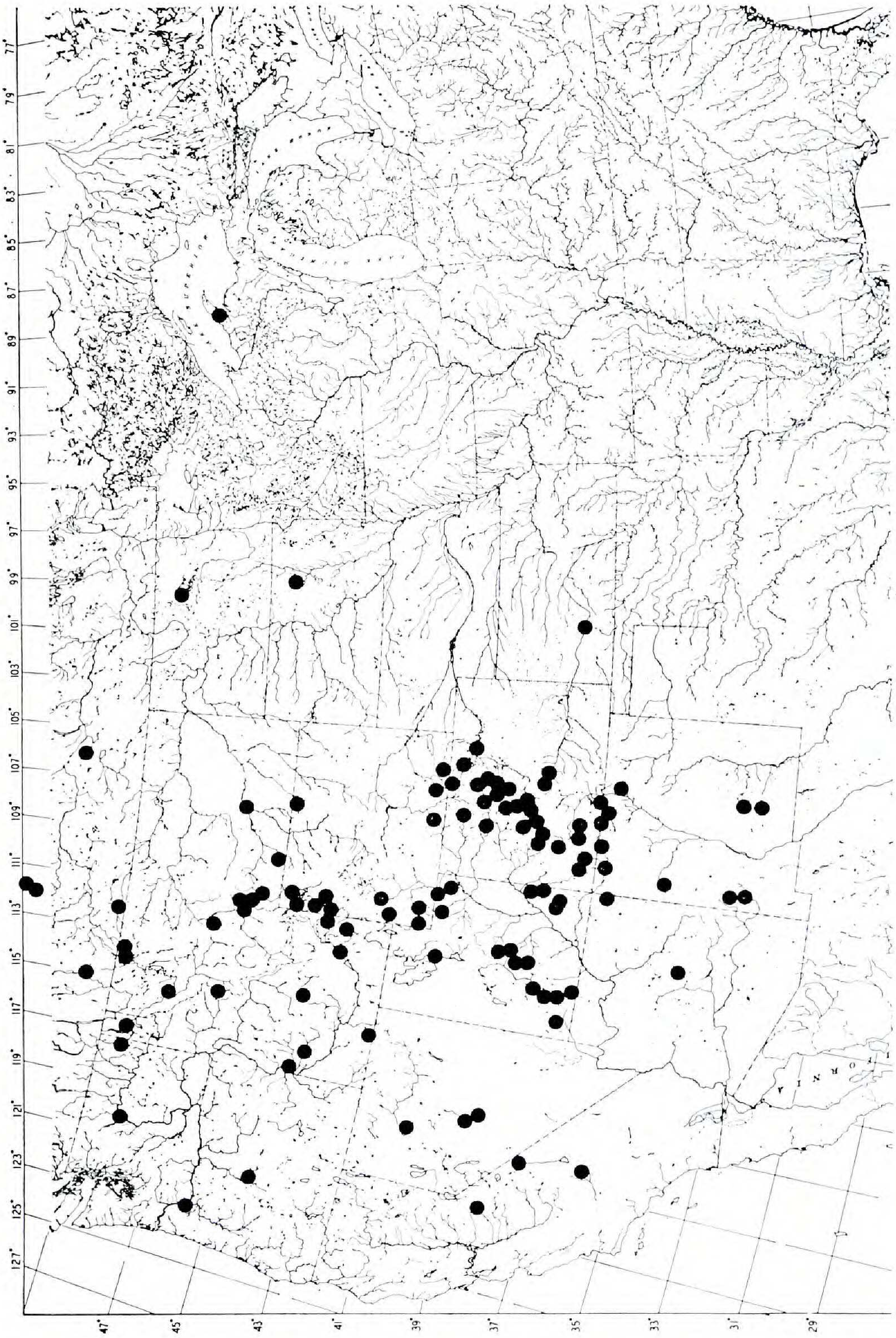
There is a good correlation of the localities with rivers and streams. The solid line represents the southern limit of Wisconsin Glaciation (after Flint *et al.*, 1959).



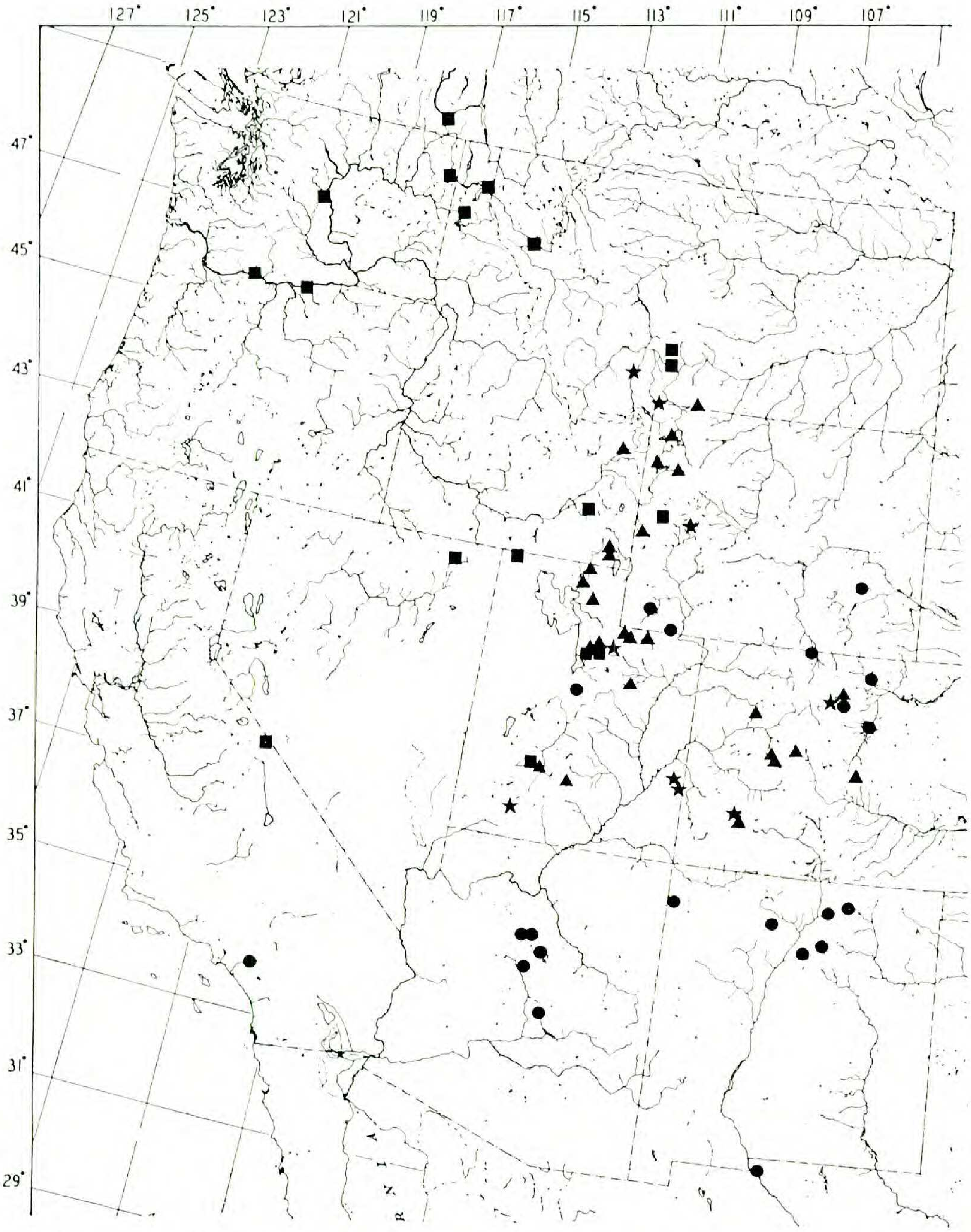
Map 10. Distribution of the pinnate-leaved species of *Rorippa* in southwestern United States, Mexico, and Central America: ■ *R. megasperma*, ● *R. pinnata*, ★ *R. intermedia*.



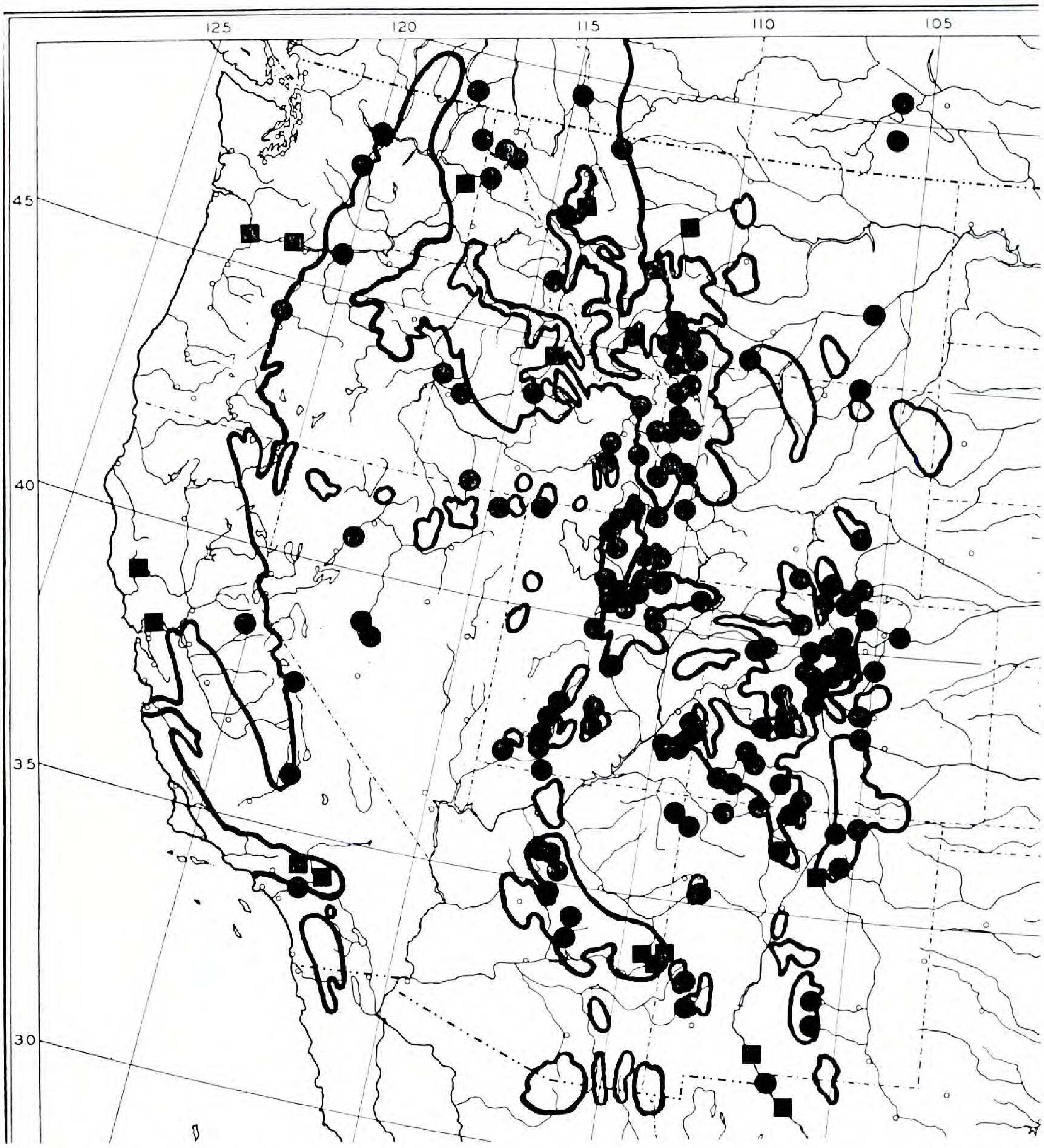
Map 11. Distribution of *Rorippa truncata* in central and western United States. This species is absent in the central Rocky Mountains. Its occurrence is outward from this region in the Rio Grande, Columbia, Platte, and Missouri River valleys.



Map 12. Distribution of *Rorippa curvipes* var. *curvipes* in western United States. The species is most abundant in the Rocky Mountains, occurring less frequently to the west and sparingly east on the plains. The record from Michigan doubtless represents an introduction.



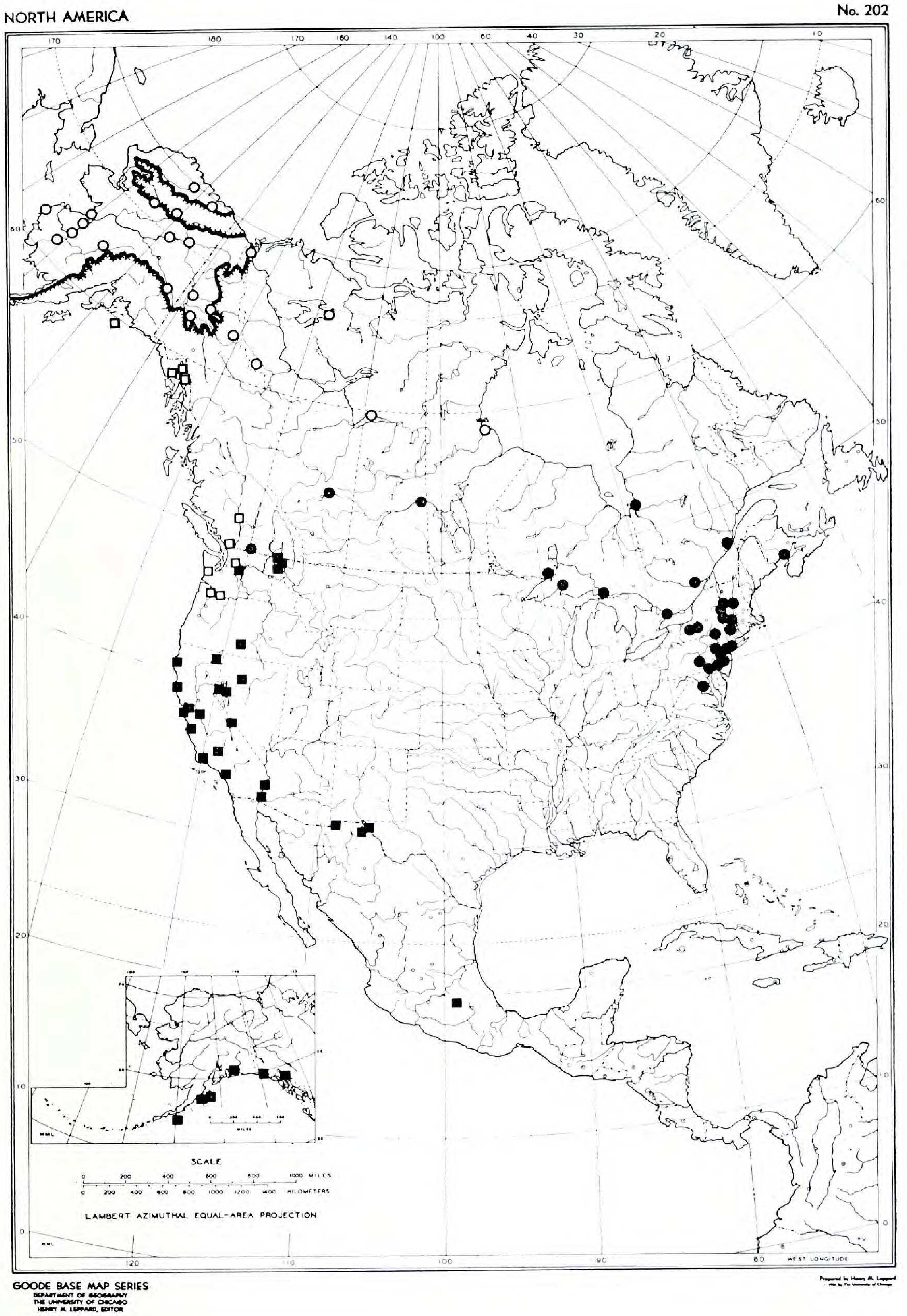
Map 13. Distribution of certain members of the *Rorippa curvipes* complex in western United States: ▲ *R. curvipes* var. *alpina* in the central Rocky Mountains. The triangles are located near the sources of the rivers, indicating that the plants come from high elevations in the mountains, mostly above 9000 feet; ★ *R. curvipes*, intermediates between var. *curvipes* and var. *alpina*. The intermediates have been found mostly along the outer limits of the range of var. *alpina*, mostly between elevations of 8,000 and 10,000 feet; ■ *R. curvipes* var. *integra* in northwestern United States. There has apparently been migration down the Columbia River; ● *R. sphaerocarpa* in southwestern United States.



Map 14. Total distribution of the *Rorippa curvipes* complex shown in relation to the 16-inch annual rainfall isohyet for western United States. (*R. curvipes* and *R. sphaerocarpa* are indicated by dots; *R. truncata* is designated by squares.)

This group of species is largely confined to an area that receives more than 16 inches of rainfall a year. (Rainfall data are taken from a 1963 ed. of a map showing normal annual total precipitation (inches), based on data from 1931-60, prepared by the Office of Climatology, U. S. Dep. of Commerce Weather Bureau, U. S. Govt. Printing Office.)

Map 15. Distribution of *Rorippa palustris* subsp. *palustris* and subsp. *occidentalis* in North America: ● *R. palustris* subsp. *palustris* var. *palustris*; ○ *R. palustris* subsp. *palustris* var. *williamsii*. The half-barred line marks the extent of Pleistocene Glaciation in northwestern North America (after Capps, 1939). The var. *williamsii* is absent from the glaciated territory of southeastern Alaska. The var. *palustris* is considered native to North America, except along the Atlantic coast south of the state of New York where the plants are believed to be introduced from western Europe. ■ *R. palustris* subsp. *occidentalis* var. *occidentalis*; ☐ *R. palustris* subsp. *occidentalis* var. *clavata*. The subsp. *occidentalis* is mostly west of the Continental Divide in the United States. In Alaska it is confined to the coast.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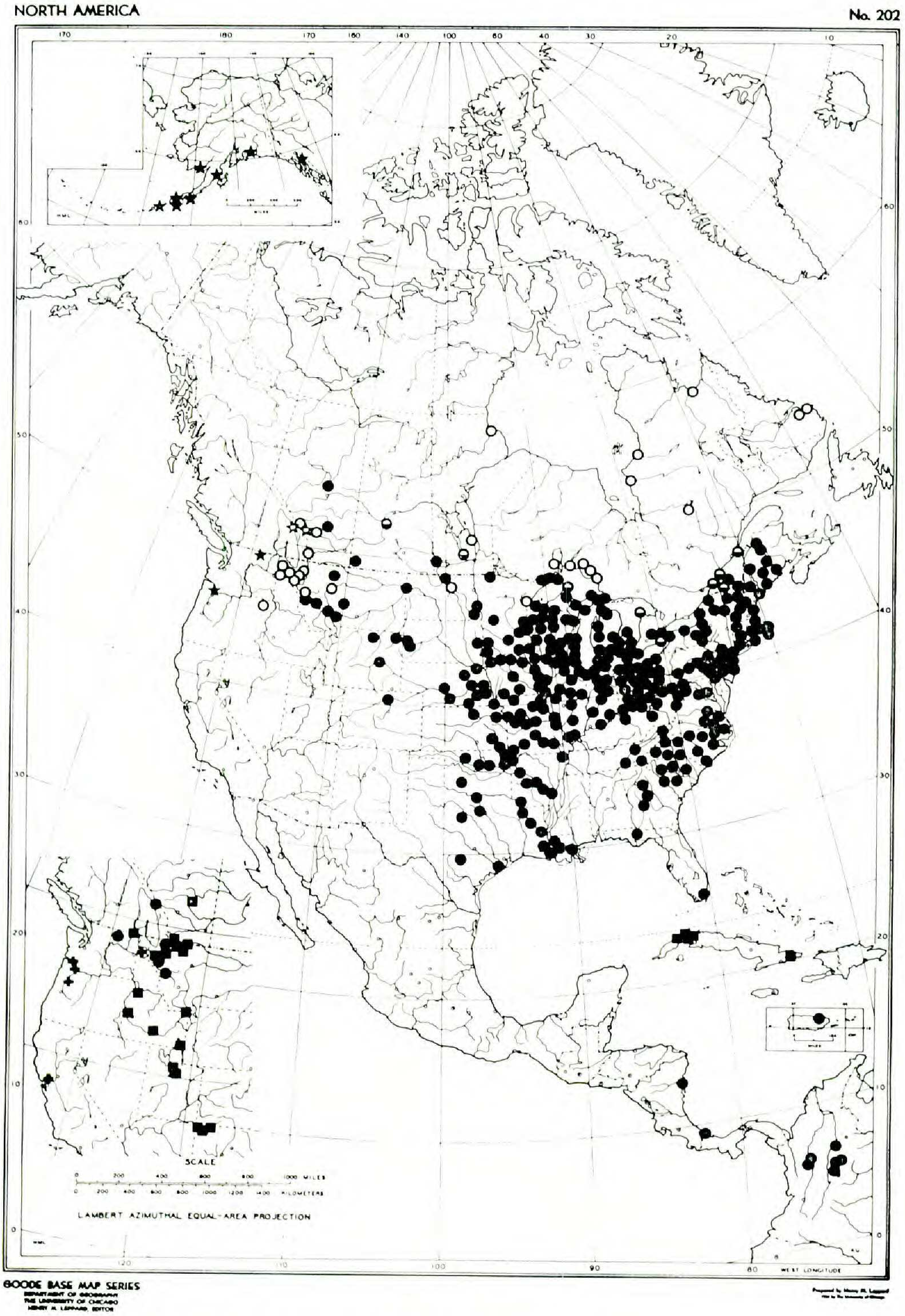
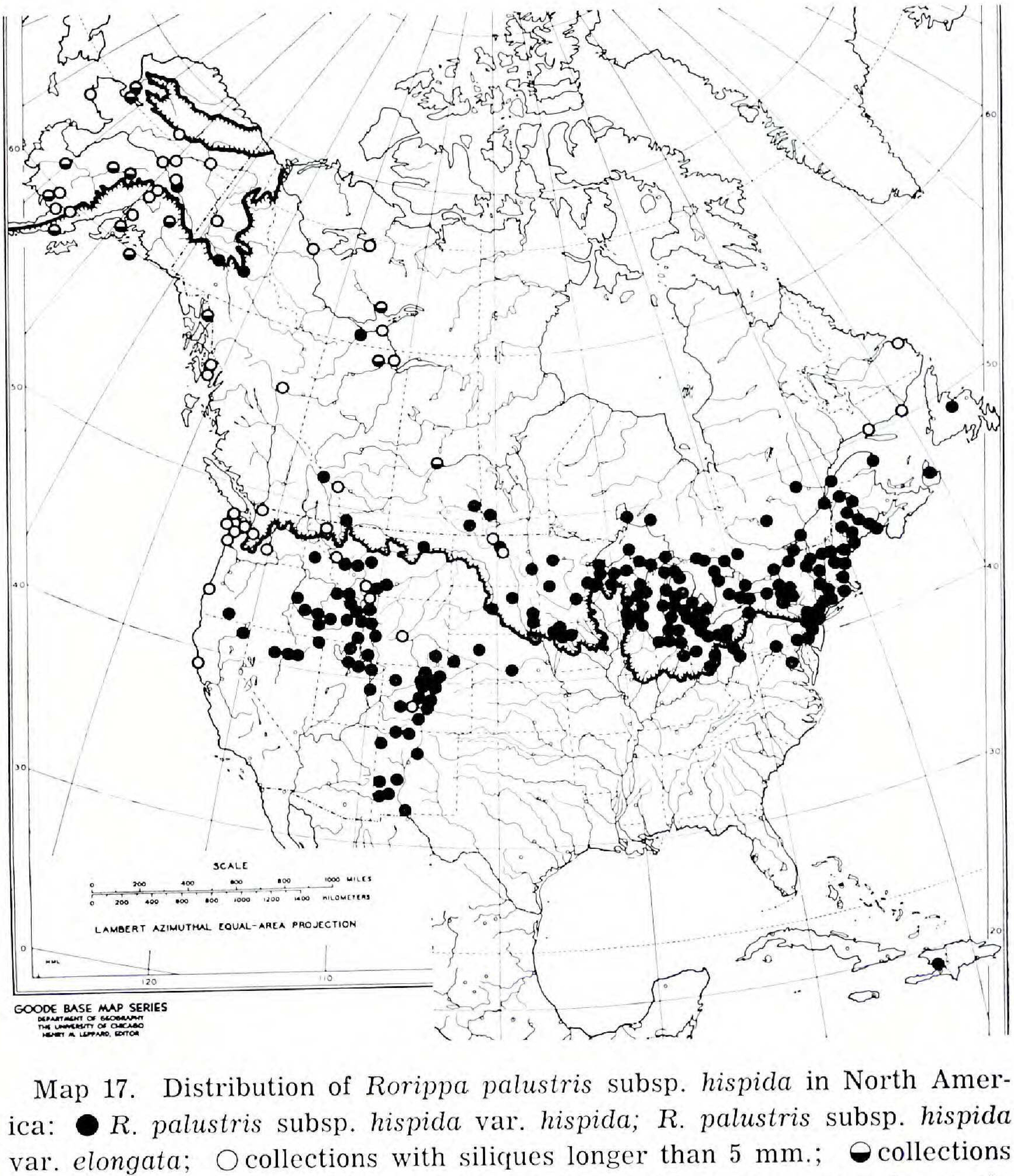


Map 16. Distribution of *Rorippa palustris* subsp. *glabra* in North America: ■ *R. palustris* subsp. *glabra* var. *glabra*; ✚ *R. palustris* subsp. *glabra* var. *dictyota*; ● *R. palustris* subsp. *glabra* var. *fernaldiana*; ○ *R. palustris* subsp. *glabra* var. *glabrata*; ★ *R. palustris* subsp. *glabra* var. *cernua*; ◒ intermediates between var. *glabrata* and var. *fernaldiana*; ☆ intermediates between var. *glabrata* and var. *cernua*.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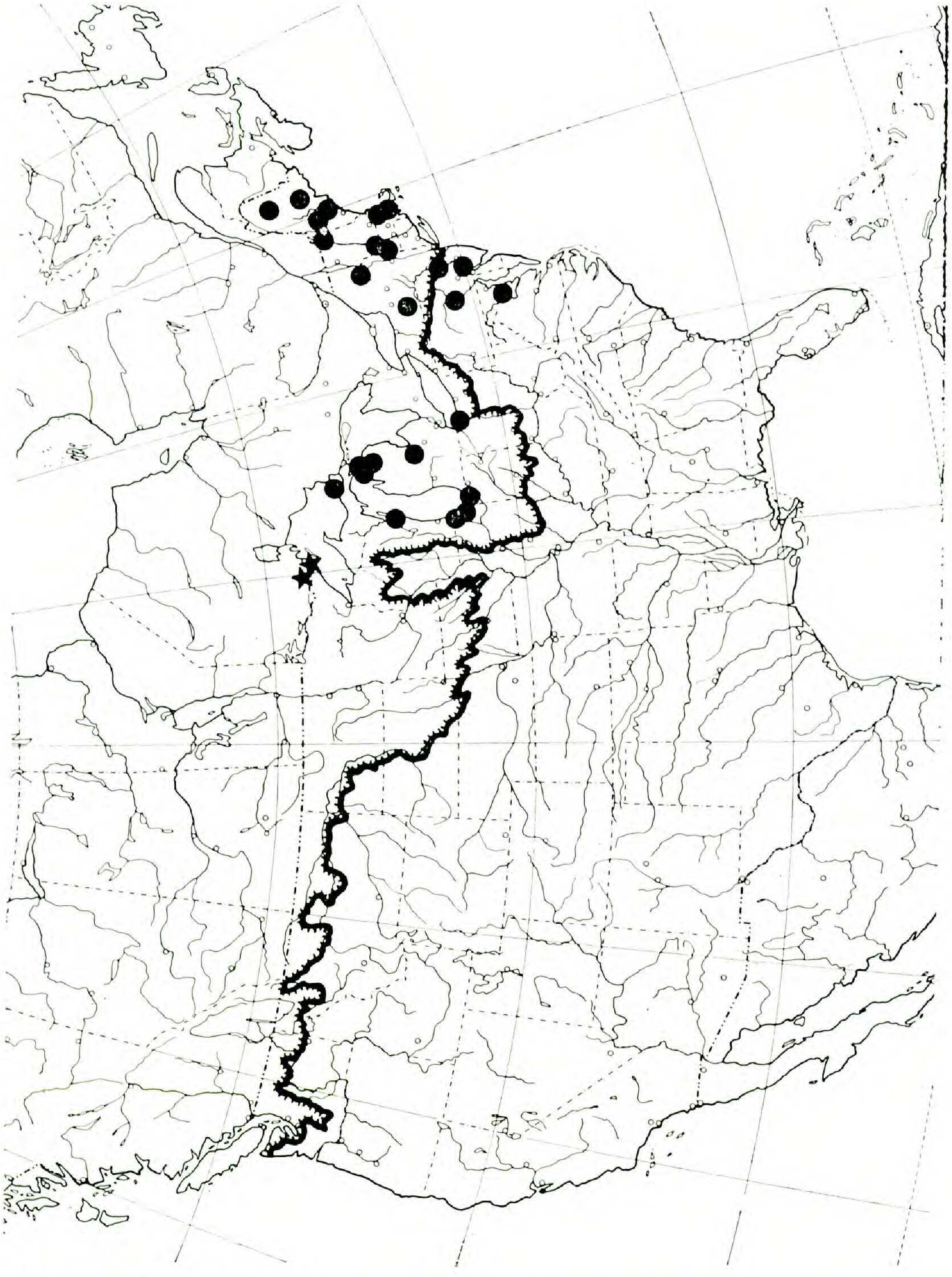
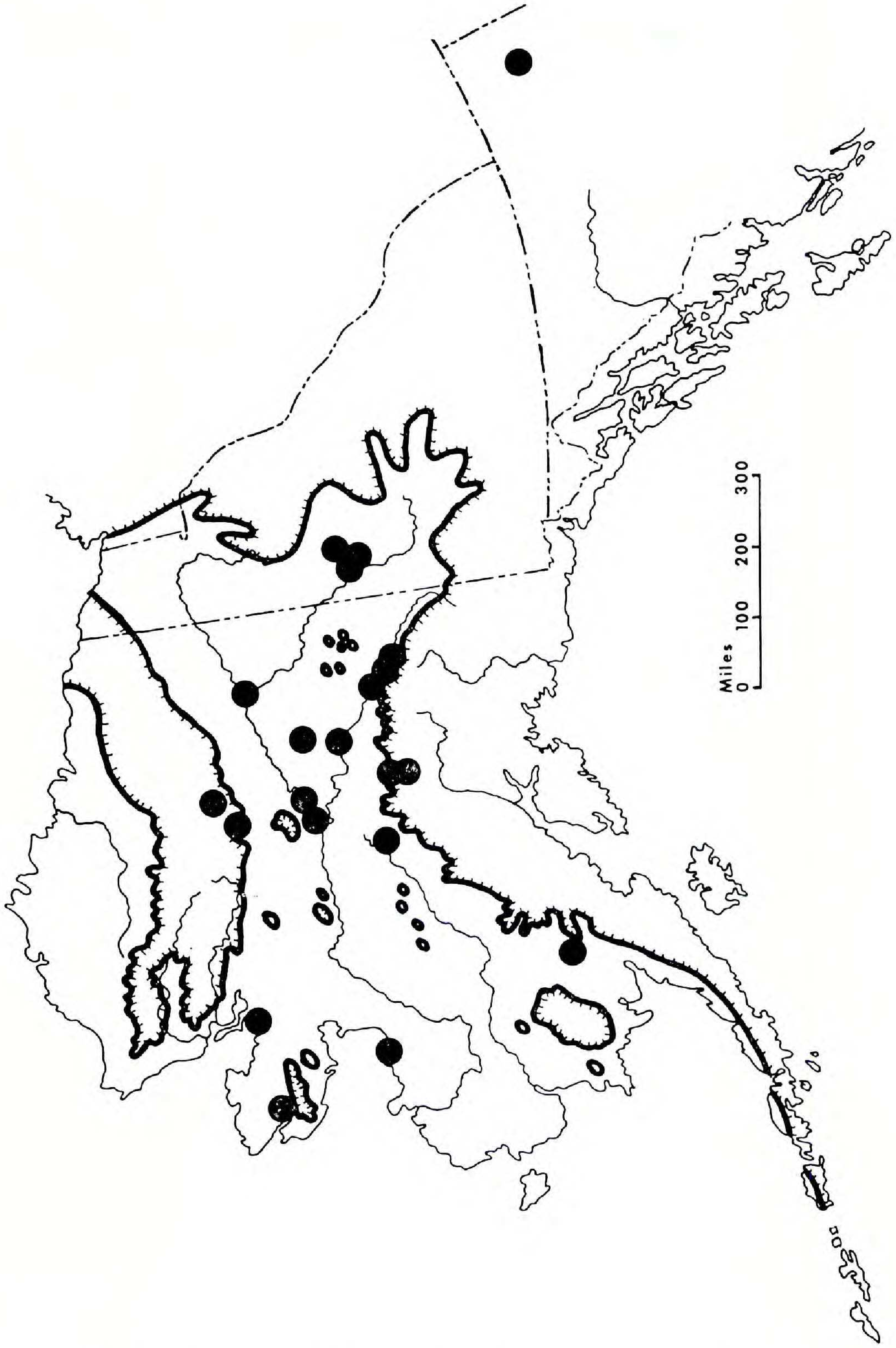
Map 17. Distribution of *Rorippa palustris* subsp. *hispida* in North America: ● *R. palustris* subsp. *hispida* var. *hispida; R. palustris* subsp. *hispida* var. *elongata*; ○ collections with siliques longer than 5 mm.; ◒ collections with siliques shorter than 5 mm. The half-barred line represents the southern limit of Wisconsin Glaciation in the United States east of the Rocky Mountains (after Flint *et al.*, 1959) and west of the Rocky Mountains (after Flint, 1957), and the extent of Pleistocene Glaciation in northwestern North America (after Capps, 1939). The var. *hispida* is mostly in the Rocky Mountain region of western United States and on glaciated territory in eastern United States. The var. *elongata* occurs along the north shore of the Gulf of the St. Lawrence. In northwestern North America it is absent from the glaciated territory of northern Alaska.

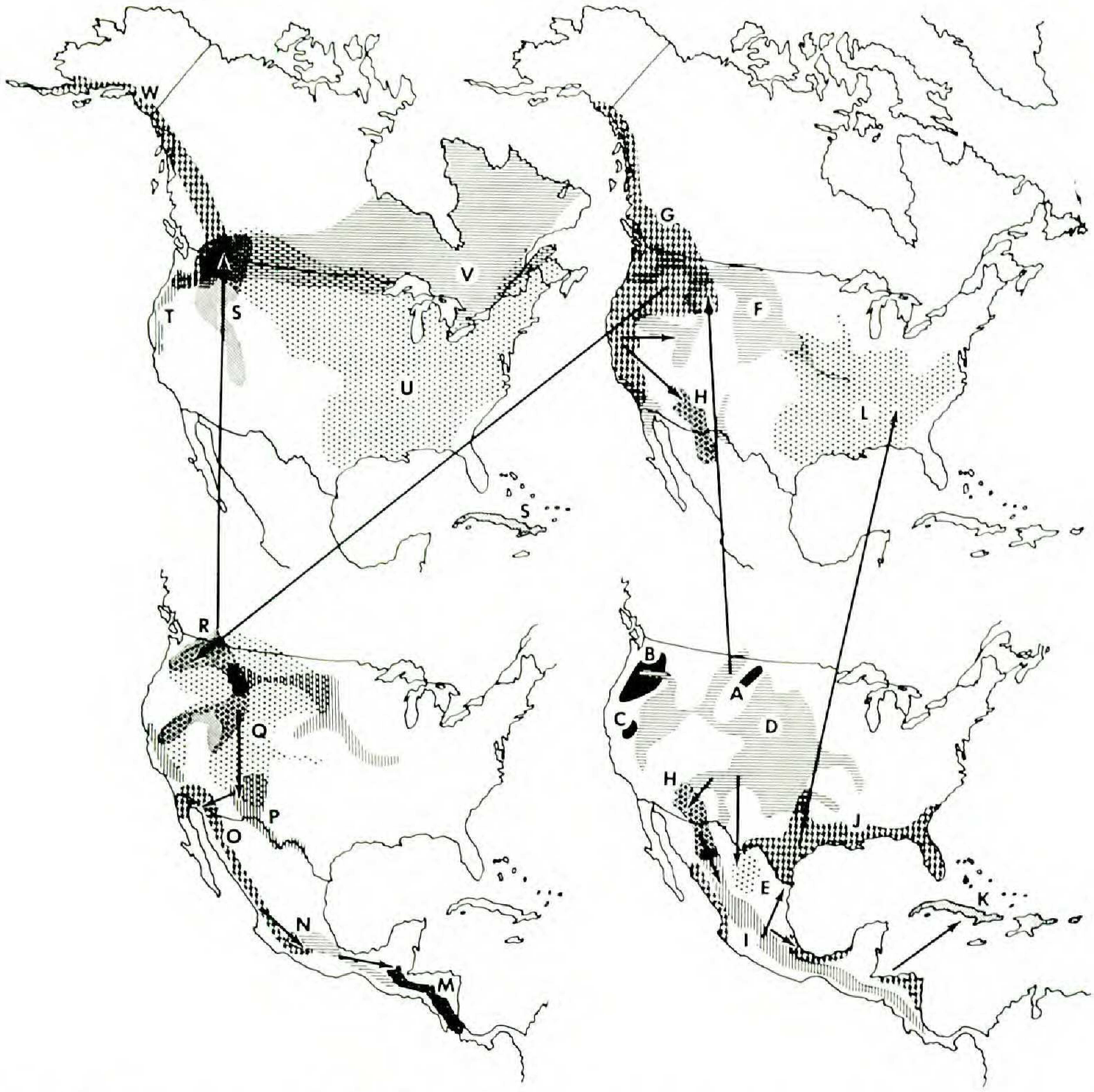


Map 18. Distribution of two hybrids within *Rorippa palustris* in glaciated eastern United States: ● *R. palustris* subsp. *hispida* var. *hispida* × subsp. *glabra* var. *fernaldiana*; ★ *R. palustris* subsp. *palustris* var. *palustris* × subsp. *hispida* var. *hispida*. The half-barred line represents the southern limit of Wisconsin Glaciation east of the Rocky Mountains (after Flint *et al.*, 1959) and west of the Rocky Mountains (after Flint, 1957).



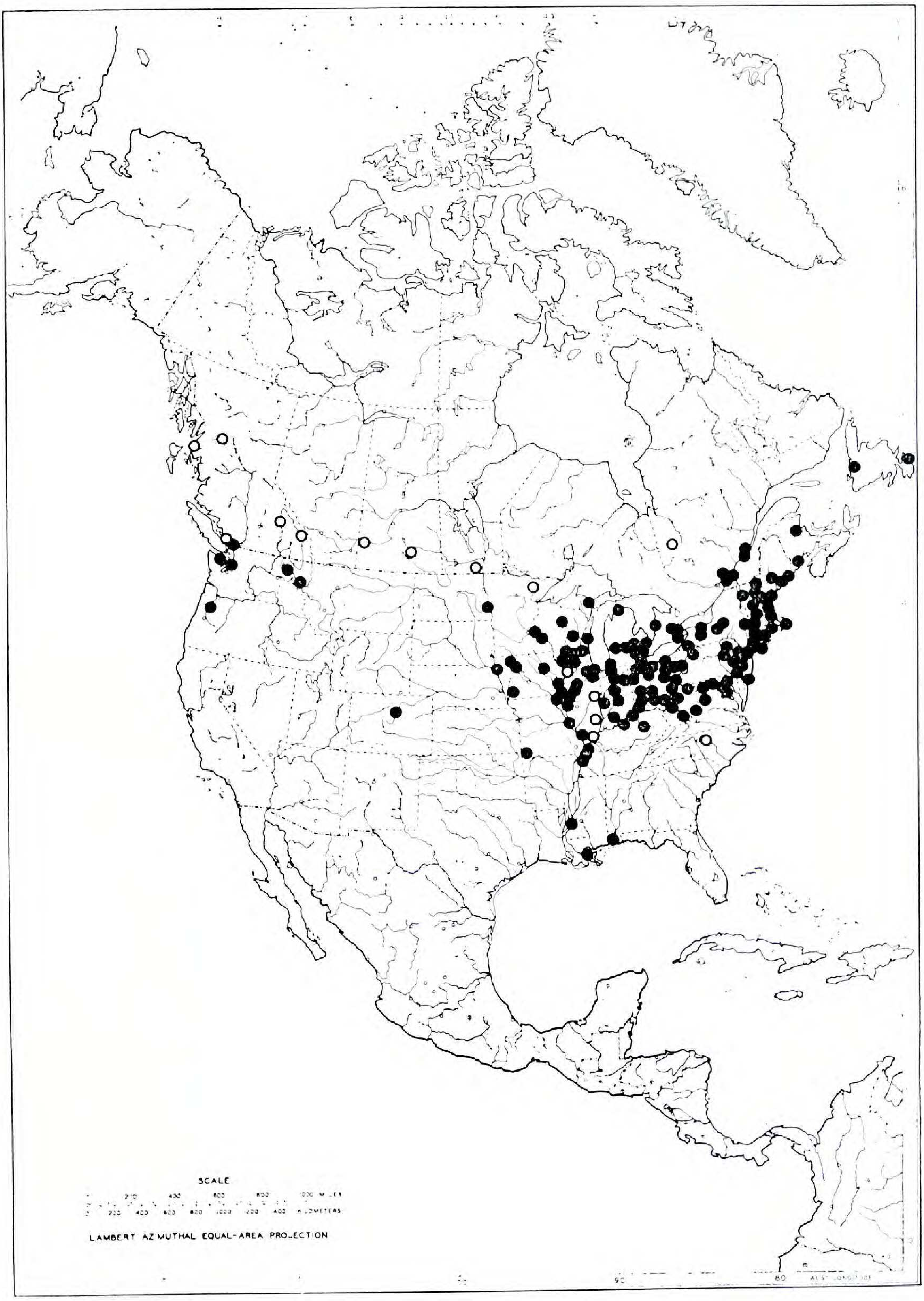
Map 19. Distribution of *Rorippa barbareifolia* in northwestern North America. The half-barred line marks the extent of Pleistocene Glaciation (after Capps, 1939). The localities are mostly from the region of unglaciated central Alaska.

GEOGRAPHICAL AND EVOLUTIONARY RELATIONSHIPS IN RORIPPA



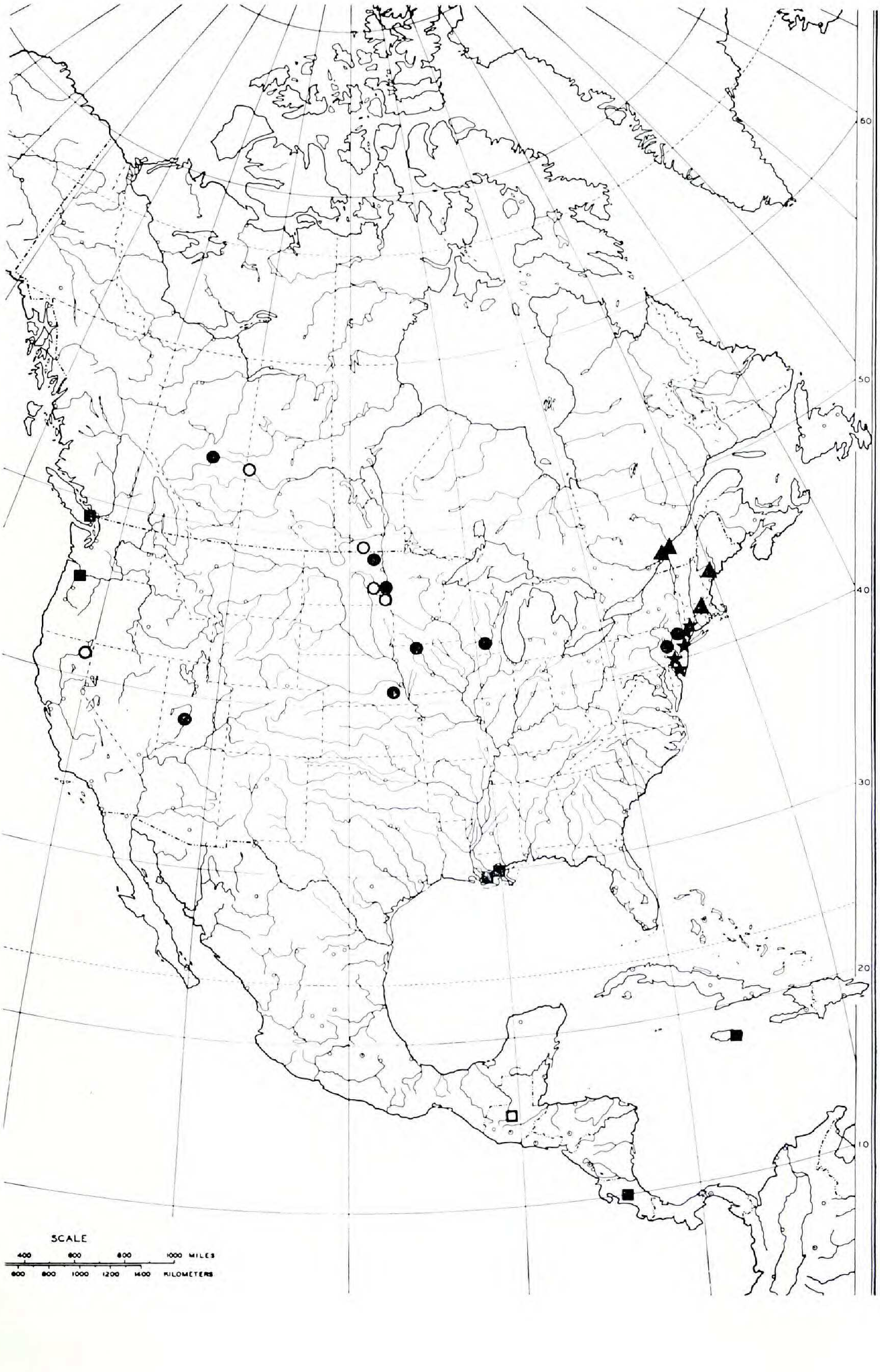
Map 20. Summary of the Geographical and Evolutionary Relationships in North American *Rorippa*.

To read the plate in its entirety, begin with taxon D, *R. sinuata*, a species with primitive characters. Additional information in the text. A. *Rorippa calycina*; B. *R. columbiae* (Map 1-A); C. *R. subumbellata* (Map 1-B); D. *R. sinuata* (Map 2); E. *R. ramosa* (Map 3); F. *R. tenerrima* (Map 4); G. *R. curvisiliqua* (Maps 5 and 6); H. *R. microtitis* (Map 6); I. *R. mexicana* (Map 8); J. *R. teres* (Map 8); K. *R. portoricensis* (Map 8); L. *R. sessiliflora* (Map 9); M. *R. megasperma* (Map 10); N. *R. pinnata* (Map 10); O. *R. intermedia* (Map 10); P. *R. truncata* (Map 11); Q. *R. curvipes* var. *curvipes* (Map 12); R. *R. curvipes* var. *integra* (Map 12); S. *R. palustris* subsp. *glabra* var. *glabra* (Map 16); T. *R. palustris* subsp. *glabra* var. *dictyota* (Map 16); U. *R. palustris* subsp. *glabra* var. *fernaldiana* (Map 16); V. *R. palustris* subsp. *glabra* var. *glabrata* (Map 16); W. *R. palustris* subsp. *glabra* var. *cernua* (Map 16).



Map 21. Distribution of *Rorippa sylvestris* in North America: ● *R. sylvestris*, based on specimens examined; ○ *R. sylvestris*, based on literature records.

Map 22. Distributions of four introduced species of *Rorippa* in North America: ● *R. austriaca*, based on specimens examined; ○ *R. austriaca*, based on literature records; ■ *R. heterophylla*, based on specimens examined; □ *R. heterophylla*, based on literature records; ▲ *R. amphibia*, based on specimens examined; ★ *R. prostrata*, based on specimens examined. These distributions do not correlate with natural physiographic or glacial features, as do those of the native species and varieties.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